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PROCEEDINGS OF THE NATIONAL WETLAND VALUES ASSESSMENT WORKSHOP

May 23 - 26, 1983
Alexandria, Virginia

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United States Department of Agriculture

U.S. Department of the Interior Office of Surface Mining

U.S. Department of Transportation
Federal Highway Administration

U.S. Fish & Wildlife Service
Department of the Interior

National Oceanic and Atmospheric Administration
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This summarizes information resulting from the Wetland Values Assessment Workshop held in Alexandria, VA from May 23-25, 1983. Forty wetlands experts from 17 sponsoring agencies discussed wetland value assessment, focusing on the method for wetland functional assessment recently prepared for the Federal Highway Administration. This method was report in "A method for wetland functional assessment," U.S. Dept. of Transportation Report FHWA-1P-82-83, Vol. I, by Paul R. Adamus. The workshop resulted in the development of a National Wetlands Values Assessment Methodology which incorporates food chain, socio-economic, hydrology, habitat, and water quality values of wetlands. Research needs and references are also included.

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FOREWORD

Progress in our ability to analyze effectively and manage components of our environment has been rapid. In the short span of a few decades, topics of environmental concern have become an integral part of our everyday lives. Industrialization and urbanization will continue as an integral part of the development of this Nation, but it can be done in such a way that we can also have a clean, productive environment. Work in the 1970's and 1980's began to focus on developing management tools that could be used in sound environmental decisionmaking. I am pleased that our progress in the understanding, assessment, and management of wetlands has kept pace with the rapidly growing environmental awareness of the public as a whole.

In the mid-1970's, an interagency effort began the laborious, yet fruitful, task of creating a National Wetlands Classification System. We are beginning to incorporate this system into routine agency wetland activities. After the first step of definition and classification, the National Wetlands Inventory began the second enormous task--delineating the wetlands of the United States. The National Wetlands Inventory has now produced maps of high-priority wetlands for 30 percent of the lower 48 States, 6 percent of Alaska, and all of Hawaii.

The third component of our effort was to develop a thorough understanding of wetlands. The results of this effort, a report entitled The Status and Trends of Wetlands and Deepwater Habitat in the Conterminous United States, 1950's to 1970's, was published in 1983. This report has made us aware that during this 20-year period, we experienced a net average annual loss of 458,000 wetland acres. This translates into an area half the size of the State of Rhode Island each year. The report also provides insights into where these net losses are taking place. Huge decreases in forested wetlands occurred in the lower Mississippi River States of Louisiana, Mississippi and Arkansas. Other losses also occurred in the Mississippi Flyway, specifically in Minnesota, Michigan, Wisconsin, Illinois, and Alabama. Large losses in inland wetlands occurred in the Central Flyway States of South Dakota, North Dakota, Nebraska and Texas. Greatest losses of wetlands in the Atlantic Flyway occurred in Florida, North Carolina, Georgia, South Carolina, Maryland, New Jersey and Delaware. The largest losses in the Pacific Flyway were in California.

Some of the functions most widely ascribed to wetlands are ground water recharge and discharge, flood storage and desynchronization, shoreline stabilization through dissipation of erosive forces, sediment trapping, nutrient retention and removal, food chain support, habitat for fish and wildlife, and active and passive recreation. Other functions sometimes ascribed to wetlands include, but are not limited to, harvest of commercial timber, crops, or peat; grazing; extraction of mineral resources; aquaculture; urban development; alteration of local and regional climate; importance to sulfur cycling and oxygen production; retention and subsequent detoxification of heavy metals and other hazardous substances; and waterborne commerce.

Wetlands vary in the opportunity they have to fulfill these functions, the degree to which their physical and chemical characteristics allow them to perform these functions. The value society places on the functions themselves also varies.

We must learn how to estimate the likelihood that any given wetland can perform these functions, and develop a framework for estimating which wetland is more important in performing these functions. These estimates will give scientists and policy makers some conception of the function of any particular wetland under discussion. Such a capability is an important link in achieving the goal of a clean and productive environment.

The task, again, is a large one. Yet, as we have shown before in the development of the Wetlands Classification System and in the National Wetlands Inventory Project, it can be done.

This workshop was the first step of the third component, producing a National Wetlands Values Assessment Methodology. We have had outstanding interagency cooperation on this project, involving 17 Federal agencies and private wildlife conservation organizations. In addition, we were fortunate to have had 3 days of undivided attention from 40 of the Nation's foremost wetlands experts. I am pleased with the results of the workshop and anticipate the day in the foreseeable future when a resource manager can use a National Wetland Value Assessment Methodology to integrate information from the Wetland Classification System and the National Wetlands Inventory into management plans that incorporate some or all of the identified wetland functional values.

Robert A Jantzen MAR 1 6 1984

Robert A. Jantzen, Director
U.S. Fish and Wildlife Service

PREFACE

This document is intended for use as a companion to the wetland evaluation methodology developed for the U.S. Department of Transportation, Federal Highway Administration (Adamus, P.R. 1983. A method for wetland functional assessment. U.S. Department of Transportation Report FHWA-1P-82-83, Vol. I, 176 pp., Vol. II, 138 pp. Washington, DC). The workshop results presented in these proceedings are the result of an ongoing effort by Federal, State, and private groups to improve on wetland evaluation techniques. The members of the sponsoring Coordinating Committee are listed in Appendix B. Results of this workshop will be used in decisionmaking by the Coordinating Committee in accordance with the four year follow-up plan presented in Appendix C. Further information on Coordinating Committee actions can be obtained by contacting Dr. Bill Wilen, Coordinating Committee Chairman, at the address listed on page 95.

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ACKNOWLEDGMENTS

Planning for a Wetland Values Assessment Workshop began during the fall of 1982. On September 9, 1982, an interagency meeting on National wetlands quality assessment was held in Fort Collins, Colorado, under the auspices of the Western Energy and Land Use Team of the U.S. Fish and Wildlife Service. Agencies that had representatives at that meeting included the Federal Highway Administration, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Soil Conservation Service, U.S. Forest Service, and U.S. Fish and Wildlife Service. This group, called the Steering Committee, was later enlarged to 17 agencies and private organizations. Additional representatives were from the International Association of Fish and Wildlife Agencies, National Marine Fisheries Service, U.S. Department of Energy, Wildlife Management Institute, U.S. Environmental Protection Agency, Office of Surface Mining, Department of Housing and Urban Development, U.S. Bureau of Land Management, National Park Service, U.S. Geological Survey, and the Federal Energy Regulatory Commission. This group was renamed the Interagency Wetlands Coordinating Committee and will likely expand its membership even further. Much appreciation goes to these agency representatives for their involvement in this project. This workshop would not have been possible without the financial sponsorship of the U.S. Army Corps of Engineers, U.S. Geological Survey, U.S. Bureau of Reclamation, National Marine Fisheries, U.S. Environmental Protection Agency, Federal Highway Administration, Office of Surface Mining, U.S. Fish and Wildlife Service, and U.S. Soil Conservation Service.

Special recognition is due the chairmen of the six Workshop Panels: Joseph Larson, Value Assessment Panel; Mark Brinson, Food Chain Panel; Robert Kadlec, Water Quality Panel; Virginia Carter, Richard Novitzki, and Thomas Winter, Hydrology Panel; Milton Weller, Habitat Panel; and William Niering, Socio-Economic Panel. They prepared and presented introductory addresses that served to set the stage for the work of their panels, chaired the panel work sessions, and prepared the panel reports that appear in these proceedings. Eugene Hester (U.S. Fish and Wildlife Service) and Charles Des Jardins (Federal Highway Administration) both took time out from their busy schedules to begin the workshop with presentations from the point of view of their respective agencies. Special recognition is also due the following individuals who, as recorders, assisted the Chairmen throughout the workshop: Nancy Bartow, Hydrology; Dan Smith, Food Chain; Pat Ruta Stuber, Habitat; Robert Hays, Value Assessment; Alan Perkins, Socio-Economic; and Lee Ischinger, Water Quality.

We also want to express our thanks to all those who participated in the panel sessions. They not only took time out to attend the workshop, but they also gave freely of their expertise during pre- and postworkshop assignments.

We are indebted to the Federal Highway Administration, especially to Douglas Smith of that agency, for permitting us to use their recently completed wetland assessment report as the focal point for this workshop. Paul Adamus, the principal author of the report, was particularly helpful throughout all phases of the project.

We owe thanks to Mr. Lee Ischinger of the U.S. Fish and Wildlife Service, who provided advice and encouragement. Special recognition is also due Ms. Linda Vendryes, who was responsible for transcribing all of the materials during the workshop sessions and the typing of these proceedings. Also, thanks to Mr. John Hoxmeier, who served as the Project Manager and handled the many detailed arrangements required for holding a productive workshop.

Finally, recognition is due Dr. Bill Wilen, National Wetland Coordinator of the U.S. Fish and Wildlife Service, for his advice and encouragement with regard to all aspects of this project and for chairing the Interagency Wetlands Coordinating Committee.

WELCOME

by
F. Eugene Hester, Deputy Director,
U.S. Fish and Wildlife Service

Ladies and Gentlemen, I am pleased to be here to welcome you to this National Wetland Values Assessment Workshop. This group needs no discussion from me concerning the unique and valuable role of wetlands in supporting diverse food chains and fish and wildlife resources and in maintaining the quality and ameliorating the fluctuation in our hydrologic systems. If our interagency steering committee did its job, you are the best experts available in our Nation at this time to discuss these functions.

This is the Fish and Wildlife Service's National Wetlands Inventory Project's third major attempt at interagency participation in areas of common interest. It will be 8 years ago this July that an interagency group launched us on the road to the development of a new wetlands classification system. The system was adopted for use by the Service in September, 1980. Thus far, we have used that system to map nearly 900,000 square miles from the north slope of Alaska to Florida and from Maine to Hawaii. Our second attempt was interagency training of people in the use of the new wetland classification system. Since our first interagency session during the fall of 1980, we have trained a few thousand biologists in the use of the system. So, where do we stand now. We have the Classification of Wetlands and Deepwater Habitats of the United States, which: (1) describes ecological units that have certain homogeneous natural attributes; (2) arranges these units in an hierarchical system that aids decisionmaking; (3) furnishes classification units for inventory and mapping; and (4) most importantly, provides a uniformity in concepts and terminology throughout the United States.

We also have a considerable amount of mapping completed that tells us how much of what type of wetlands exist and where. But a classification system and maps alone are not an assessment system. We purposely did not incorporate our (meaning interagency) value system into our classification system because it would have made the classification inflexible in terms of increasing our knowledge and would have overemphasized our biases at the time of writing. We did our best to provide the information that would be needed to make value assessments, such as vegetation life form, substrate type, water regime, water chemistry, soils, and man's influence. The Federal Highway Administration's wetlands functional assessment method has taken these categories and ranked them as to their effectiveness, given the opportunity to perform the twelve wetland functions.

If you, as a group, determine that the wetland classes, subclasses, substrate types, water regimes, etc., are ranked correctly as to their effectiveness to perform various functions and if the Value Assessment panel determines that the method can be practically applied in a cost effective manner, we will have the essential information needed to effectively evaluate management alternatives. All of us need rapidly accessible and easily understandable wetland data in support of our responsibilities for environmental review, decisionmaking, and action on specific projects pursuant to the National Environmental Policy Act and Executive Order 11990 for the Protection of Wetlands. We will all benefit from a good method for the evaluation of possible impacts of proposed projects on wetlands.

A mutually agreeable, polished evaluation method will not be completed in the next 4 days, weeks, or months. The job of the steering committee will be to take the result of this workshop and do what is necessary to achieve that goal.

I thank you now for your efforts in the upcoming 3 days.

WELCOME

by
Charles Des Jardins, Chief Ecologist
Office of Environmental Policy
Federal Highway Administration

Good morning. I would like to welcome everyone to Washington. The Federal Highway Administration (FHWA) is very, very pleased to be a participating member in this conference. It was not an effort on our part, to even think twice about contributing financially and to also contribute our technical expertise to this particular conference.

The FHWA and its activities over many, many years, especially since 1970 when the National Environmental Policy Act (NEPA) was passed, have had many both positive and negative impacts on wetlands. As I have travelled around the country, I have seen sad tales of wetland loss and I have seen positive signs. Although, in many cases, wetlands exist by accident; very few were intentionally created until recently.

In implementing NEPA, wetlands were just one of many resources that we had to deal with in our impact assessments. When President Carter signed Executive Order 11990 in 1976, this sharpened our focus on wetlands and we, as an agency, have taken that particular Executive Order very, very seriously. I think that our concern is well documented. I mentioned last week at an Ecology training course conducted by FHWA in Atlanta, that even if the presidential Executive Order was cancelled, our concern for wetlands would continue. I think our direction and our momentum is strong enough now that the research, interest, and concern for wetlands as a National resource is well established. With that I am very pleased.

We also realize, as an agency, that wetland values are not only National and local, but they also are obviously international. I am sure the Russian and the Japanese fishermen offshore are not aware of it, but the values of wetlands are obviously international.

Since 1976, with the signing of the Executive Order, we have been gathering information on the creation or techniques of creating new wetlands along with construction to lessen impacts. We have 50 highway departments all trying to incorporate Federal guidelines in the protection of wetlands, so we have many, many different techniques being used. Communication aspects are sometimes very difficult, and one role that those of us in the Washington Office try to play is to capture those good things that have happened and make them known so that other highway departments, other Federal agencies, and State agencies can use the successes and also learn from the failures.

Always, as a policy statement, even though we get wrapped up in the creation of wetlands and wetland values, we continually find, in our State highway departments and our Federal highway activities, that avoidance of wetland impacts is the first concern.

Now getting into an area that is more pertinent to our conference here, the FHWA wetland functional assessment is our effort for a comprehensive system which is developed or directed towards highway development activities. It is not our intention, nor will it ever be our intention, to mandate any system. We look upon it merely as a tool for resource analysis, a tool for the decisionmaker to have a better knowledge of the value of wetlands, so that he or she can compare that with all the other particular resource values that must be dealt with. Again, I think that it is very important to look upon it as a tool and never as a mandatory requirement. I think it is also important in fostering the interagency cooperation that Dr. Hester mentioned. I am sure you are aware, if not, you will be by the end of the week, that we have incorporated the Fish and Wildlife Service wetland classification system into our methodology. In fact, as far as policy guidance issues, we have not mandated such, but we have highly recommended that our State highway departments, in the preparation of their environmental statements and their environmental analyses, classify wetlands by the use of the Fish and Wildlife Service classification system. I would like to report here that not all, but over 90 percent, of the highway departments, have incorporated the Fish and Wildlife Service classification system. I am sure that in the next year or two the last few will be switching over.

So, from that point, we are very happy and very proud that we have had a part in the advance in the knowledge of wetlands. We also, as an agency, plan to continue improving what we have done. We do not plan to sit and rest with what we have accomplished. We look for guidance and direction in this conference from each and every one of you. We also look, as an interagency cooperation measure with many agencies, to find our proper niche in the research and development area so that the agencies do not overlap. We obviously, each and every one of us, know that we have many areas to research, and we to not need to have two agencies working or researching in the same problem area. As an agency, and I as an individual, challenge each and every one of you to continue this momentum that was started in 1975 at the National Wetlands Conference that was held in College Park. I see quite a few faces I recognize and I know were at that conference. I think this is just another effort in furthering the advance in wetland knowledge. We look forward to the comments from this conference, and we look forward to the conference attendees providing us with the best direction for research efforts.

WORKSHOP SUMMARY

by
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INTRODUCTION

This is a summary of the information emanating from the Wetland Values Assessment Workshop held in Alexandria, Virginia, from May 23-25, 1983. This workshop was limited to 40 invited participants, selected from a list of individuals recommended by the sponsoring agencies. Individuals on this list were recognized as being on the "cutting edge" of work associated with one or more of the major functions attributed to wetlands. An earnest attempt was made in the selection of participants to ensure a balanced representation of the applied and theoretical aspects of wetland functions and Federal, State, and private spheres of interest. We also tried to balance geographic and wetland type (coastal vs. noncoastal) representation. This was not an easy chore, especially with regard to certain functional areas.

Participants were asked to focus their attention on the central issue of wetland value assessment, particularly on the method for wetland functional assessment recently prepared for the Federal Highway Administration (FHWA) (Adamus 1983). This was the first time the FHWA system had been so intensively studied by such a broad range of recognized wetland experts.

Workshop participants were furnished with a copy of the system approximately a month prior to the workshop. To my knowledge, the wetland and deepwater classification system of Cowardin et al. (1979) is the only other recent methodology that has been subjected to such a thorough and penetrating review.

Dr. John Kadlec, a participant in the workshop, recently prepared a review of a report that was technically similar to the FHWA report studied at this workshop. He has given me permission to quote some excerpts from his review; I think the reader will find Dr. Kadlec's comments helpful in setting the stage for a balanced interpretation of the criticisms and suggestions emanating from this workshop. His comments are as follows:

> You should be aware that any technically highly competent person could 'nit-pik' and find contrary evidence for almost all statements in this document.
>
> You should not expect to find, or be able to demonstrate, nice simple cause and effect relationships. That doesn't mean there is not a very important relationship -- just that it is harder to understand and qualify. Think back to our view of pesticides 20 years ago --- it took us a long time to understand the complex pathways through which pesticide effects are manifested. So too the relationships between wetlands and their various functions. The message is: Don't take the absence of simple cause and effect to mean no cause and effect!

Many of the recommendations and observations included in the workshop panel reports are highly specific and primarily of value to persons who may eventually be involved in revising the FHWA system. The reader is referred to the panel reports for such details. This summary is limited to those major criticisms and recommendations that may be helpful to persons who are interested in whether or not this particular system can be adapted to fit the needs of a broad spectrum of users on a National basis. The material is organized under appropriate headings, and it represents my personal interpretation of information contained in the workshop panel reports. It is hoped that the information emanating from this workshop can be utilized to develop a standardized National system of wetland value assessment that will fit the needs of all users.

OVERALL APPRAISAL

Inasmuch as the FHWA System is based on what is currently known about wetland functions, it is understandably better suited to the evaluation of some functions than others. Several panelists, especially those serving on the Hydrology and Food Chain panels, had serious reservations about the wisdom of utilizing such a system in light of serious gaps in our knowledge of certain wetland functions. Despite some highly critical comments focusing on specific portions of the FHWA system, the overall assessment was positive. The following statements from some of the panel reports attest to the positive evaluation.

1. We find the concept sound. The framework is good, but incomplete in outline. (Value Assessment Panel)
2. While written for use by the FHWA, it appears to have general potential for use by managers and decisionmakers as a tool for planning, impact assessment, inventory, and a variety of other purposes. (Hydrology Panel)
3. A modified version of the FHWA assessment procedure can be successfully used. (Water Quality Panel)
4. The FHWA method is the most complete and thorough procedure of its kind created to date. (Habitat Panel)

5. It is a system that is based on a survey of the current literature. (Hydrology Panel)

FORMAT

The following is a summary of suggestions made by panels with regard to the structure of the FHWA system:

1. In introducing the system, it is essential that a flow chart be provided that clearly illustrates how the system works. At the present time, such a flow chart is not provided until the user reaches Volume II.

2. Red Flag, Functional Support, and Socio-economic Utilization Potential (Human Significance) factors should be incorporated in the flow chart. If sufficient Red Flag values exist, there would be no need to go any further with the procedure. The addition of the Functional Support feature would help clarify the fact that certain physical factors (e.g., hydrology, geology, and topography) can best be regarded as forcing functions or driving forces. The Socio-economic Utilization potential feature could be incorporated in a flow chart between the present Functional Value and Functional Significance features. The Functional Significance feature could probably best be viewed as the Ecosystem Significance feature. If these suggestions were followed, the flow chart would look somewhat like the following:

3. The system should be rearranged so that it is clear that there is a step-by-step procedure based on predictors that leads logically towards an end point. In other words, as one goes through the system, it should be obvious that there is a steady progression towards a goal. The predictors should be arranged in a hierarchical manner, progressing from those of broadest implications to those of most specific implications.

4. The distinctions between the levels of information obtained in the office, reconnaissance trips to the field, and detailed field work should be more clearly delineated.

5. The whole system needs to be reorganized to achieve greater ease of use. In this regard, a computer software package should be developed to facilitate use of the system.

6. Inasmuch as there are so many commonalities between principal wetland types, it may be helpful to develop subsets of predictors that are relevant to each of those types.

7. Greater use should be made of graphics, and several of the graphics used in the current document should be upgraded.

8. Serious consideration should be given to changing the three-tier rating system (High-Medium-Low) to a five-tier system. A five-tier system may encourage more serious consideration of wetland values in the decisionmaking process and, thereby, lead to greater precision.

9. Because of significant regional differences in wetlands and human perceptions of wetlands, regionalization of portions of the standard National system is essential. Wetland classification and regionalization should be "up-front" aspects of the system.

10. In addition to the "Yes" and "No" categories on the forms, a "No Data" column should be included. The proportion of "No Data" responses could be used to assign a validity modifier to a particular evaluation result.

FACTUAL WEAKNESSES

1. The amount of literature reviewed in the FHWA document is truly noteworthy; however, there is still a great need for a more careful synthesis and interpretation of the literature for certain areas. Members of the Food Chain and Water Quality Panels found several instances of misinterpretation of research findings. This was especially noticeable in those cases where the misinterpretations involved the work of authors who were serving as members of the panel. Inasmuch as the system is based on current literature, it is absolutely essential that interpretations be accurate.

2. There needs to be a very careful reevaluation of the basic assumptions on which the evaluation of the food chain function is based. The members of the Food Chain Panel either disagree with the following basic assumptions or believe that there is insufficient information available to generalize about these assumptions for the purpose of ranking wetlands. The basic assumptions questioned were: (1) wetlands have a significantly greater net primary productivity than terrestrial or aquatic ecosystems; (2) there is greater transport of food from wetlands to aquatic consumers than from other ecosystems to aquatic consumers, and greater transport of food from those wetlands with greater downstream transport mechanisms (flushing); and (3) that more flushing, more nutrients, and more or faster decomposition result in better food chain support.

3. The habitat assessment section needs to be expanded to cover a much broader range of the wetland biota, especially certain vertebrate groups (fish, amphibians, and reptiles) and plants. Also, more attention should be devoted to the guilding concept (layering).

4. To be a National evaluation system, the system will have to be expanded to include wetland values unique to Hawaii and Alaska.

DATA COLLECTION

1. Greater emphasis needs to be placed on the dynamic nature of wetland ecosystems. More than a one-time look at a wetland may be needed to make a valid assessment. In some areas, the assessment needs to reflect mean water and habitat conditions over a series of years.

2. In all applications of the methodology, there should be a reconnaissance field visit. These visits should include contacts with local people who may be knowledgeable about the condition and functions of the wetlands and watershed in question.

FIELD TESTING

1. The FHWA system needs to be subjected to intensive field testing. The tests should be conducted on a sample of wetlands for which there is a good database derived from long term research studies. The field testing needs to also involve several wetland types within all of the five systems recognized in the new U.S. Fish and Wildlife Services wetland classification system (Cowardin et al. 1979).

2. Intensive field testing involving the intended users of the system needs to be conducted. Feedback from these tests will help ensure the development of a methodology that can and will be used by a broad spectrum of users.

TRAINING

1. Intensive training sessions in the use of the evaluation system are essential. Such training sessions are necessary to ensure uniformity in application of the system, because the background of potential users covers a broad spectrum of educational and working experiences.

RESEARCH NEEDS

A. Food Chain Values

1. There is a fundamental dearth of knowledge about how food chains function, which may be an indication of how poorly we understand the relationship between primary and secondary productivity. The Food Chain Panel recommended that research activities focus on three general research questions:

   What is the relationship between the amount of primary production that occurs in a wetland and the amount of secondary production within the wetland and in the wetland basin?

   What is the relationship between the amount of primary production that occurs in a wetland and the quality and quantity of organic matter available to support secondary producers within the wetland and in the wetland basin?

   What are the food chain relationships between wetlands and adjoining open water areas, and how does the coupling of wetlands affect food chain relationships within the wetland basin?

This proposed research effort should be preceeded by a literature synthesis that addresses hypotheses based on the following components: (1) the relationship of primary productivity to fish and wildlife production; (2) the nature of coupling between wetland and open water areas of the basin; and (3) the quality of food available and its value in food chains. After careful review by peers, the literature synthesis should be followed by a workshop of food chain researchers with expertise in a variety of wetland types. The workshop participants would formulate the hypotheses, assumptions, and predictors that would be tested for their applicability to a broad spectrum of wetland types.

B. Socio-Economic Values

1. There is a need for a thorough literature synthesis. This should be a very selective effort to document what is and is not known about the socio-economic values of wetlands.

2. On the global scale, our knowledge is incomplete in terms of the biospheric significance of wetlands as an aid to our life support

system. Can the uncontrolled incremental destruction of wetlands have unfortunate consequences on a global basis? A large gap in our knowledge exists in relating individual wetlands to such far reaching values (cumulative effects).

3. What are the demographic relationships related to the wetland socio-economic utilization potential?

4. We need more interdisciplinary (e.g., physical and life scientists, social scientists, and landscape designers) studies dealing with the experiential values of wetlands.

5. How generalizable are the predictors of wetland values?

C. Hydrology Values

1. We lack the knowledge, other than that obtained through extensive field studies, needed to evaluate ground water recharge and discharge processes within wetlands. The results of current research activities lead us to question some of our traditional basic assumptions concerning ground water phenomena. Therefore, basing an evaluation on existing literature may be of questionable value.

2. In semiarid and arid regions (evaporation is greater than precipitation) with low permeability surficial deposits, it is possible to map areas of discharge using indicator species. Further research might identify plant or chemical indicators of discharge in other areas.

3. There is a definite need for more research on how to measure evapotranspiration rates.

4. Runoff is a surface water process that is poorly understood. The geo-chemistry of surface water also needs to be better understood in order to improve our ability to assess the water quality functions of wetlands.

5. More research is needed on the flood storage, flood peak desynchronization, and shoreline anchoring functions of wetlands.

6. Research activities should be long term in nature and conducted at type localities, chosen on the basis of climate, geology, and vegetation. Research sites should be typical wetlands where study results will have transfer value to the regional area.

D. Habitat Values

1. We need more studies that relate plant communities to water depth, water chemistry, and invertebrate and vertebrate fauna.

2. We need to understand how vertebrate populations are affected by community structure and the physical characteristics of the wetland. Long term studies are especially needed to relate the dynamics of the vertebrate community to the dynamics of the hydrology, water chemistry, and plant community in the wetland.

5. Special attention needs to be devoted to studies of fish, amphibians, and reptiles in wetlands. Such studies are needed in all wetlands, but knowledge of these vertebrate groups is particularly lacking in inland fresh water wetlands.

E. Water Quality Values

1. The panel felt that the assessment procedure could be made operational without additional research projects, but that the results of research in the following areas would significantly improve the procedure: sediment processes; threshold loadings; microbiology of wetlands; and the generation of detritus.

REFERENCES

Adamus, P.R. 1983. A method for wetland functional assessment. U.S. Dept. of Transportation Report FHWA-1P-82-83, Vol. I, 176 pp., Vol. II., 138 pp. Washington, DC.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetland and deepwater habitats of the United States. U.S. Fish Wildl. Serv. FWS/OBS-79/31. 103 pp.

VALUE ASSESSMENT PANEL

Joseph Larson (Chairman), Jon Duyvejonck, Eric Fried, Nancy Koffman, L. A. Shabman, Mel Thomas, Charles Wolverton, Bob Hays (Recorder).

SYSTEM USERS AND NEEDS

The FHWA system is fast enough to be useful when there is limited time available for assessment, but the user must be trained. A computer program and a better illustrated text would help in both applications and training. The system is useful for the early information steps in long range planning, but this type of user will want to go into much greater depth than this system provides. It will be useful in facility development planning and as a first step in county or basinwide summaries. The FHWA system will not be useful for species enhancement planning; we would expect the existing Habitat Evaluation System (HES) and Habitat Evaluation Procedures (HEP) systems to be used for this type of planning.

The FHWA system will not be helpful in measuring cumulative impacts, but it can be used to start a database for this kind of assessment. No known system can currently access cumulative effects. Use of the FHWA system may promote a one time look at most wetlands, even though some wetlands, in areas where precipitation is highly variable, are dynamic over a short number of years. On the other hand, when preciptation is relatively constant, wetlands may change appreciably over a 20-year period. Although instructions on page 128, Volume II of the FHWA report (Adamus 1983) call for repeated assessments at the wet, dry, and average wetness conditions, this appears to be in reference to 1 calendar year. Wetland dynamics may require several years of measurement in order to describe the dynamics related to preciptation or plant succession.

The Assessment Panel endorses the use of a "red flag" procedure, applied prior to, and outside of, the FHWA system in order to identify wetlands of unique importance. The wildlife assessment portion of the system needs to be expanded to cover other vertebrates and plants. We were tempted to recommend that the FHWA system be enlarged to cover agriculture and forestry. However, we recognize that if agriculture actually involved total wetland alteration, other activities would logically have to be included. We believe that an assessment of forest harvesting could be included along with other wetland product activities.

We addressed a series of questions concerning FHWA system applications, problems, and potential conflicts. Areas considered included mitigation/compensation, cumulative impacts, conflicting wetland functions and products, calibration of the system, and adequacy of the ranking system. It became evident that a number of the questions about system performance cannot be answered yet because field testing has barely begun. We urge system testing on a sample of wetlands for which there is a good database; derived from a long history of research. The tested sample should include wetlands that are representative of each wetland function across the FHWA system's scale from high to low. Testing against known conditions will demonstrate how well the system approximates reality. Where the system fails, it can be fine tuned and the 75 predictors calibrated to an acceptable degree of accuracy. This step will help determine if the high, medium, and low ranking framework is adequate or if a scale with more divisions is needed.

The system is not primarily intended for addressing mitigation/compensation questions. It can be used to help establish baseline information for this activity, but a determination of how well it will perform in mitigation/compensation activities will have to await field calibration.

The question was raised as to whether the 75 predictors in the system should be treated with equal importance or whether those that have broad effects across the various wetland functions should be given more weight. We perceive that the system has weight built into it in the keys and that field calibration will determine if the weight is adequate. To some degree, our experience in evaluating the FHWA system has been like looking at a model plane before it has been tested in a wind tunnel. The design shows promise, but the actual response to known conditions has not yet been tested.

What should be the outcome of the field calibration? We should expect the system to discriminate reasonably well among wetlands where different levels of a particular function have been documented. The outcome should produce an assessment consistent with the presumption of avoidance of adverse wetland impacts, as embodied in Executive Order 11990, the Clean Water Act, and similar State statutes. The user should expect the FHWA system to provide information that will help a developer avoid adverse wetland impacts, except under the most pressing circumstances.

The question of competing products and functions of wetlands is best addressed by using the system to analyze each function separately, without any attempt to force a sum value on the wetland.

The system should provide a better information base than is available via other methodologies, but cannot substitute for agency management and staff expertise in the mandated assessment of trade-offs and alternatives. We recommend that individuals completing the summary on Form D of the FHWA system review and identify the conflicting products and functions for the wetland analyzed. This type of action is illustrated in the compatibility matrix in Figure 1, Volume I of Adamus (1983).

We expect that regionalization of the system will improve accuracy. Elements can be added to, or subtracted from, the system, but the heirarchical nature of the system should not be violated in order to prevent giving rise to 50 or more evaluation systems. The Bailey ecoregion system might be a likely pattern of regionalization, but we look to the other Panels to take the lead in this matter.

MITIGATION

The FHWA system provides the technical basis for developing mitigation alternatives. But Procedure III, as presently written, is a policy statement of a single agency and not an assessment procedure. We believe that, in future drafts designed for testing by other agencies, Procedure III should be eliminated.

SIGNIFICANCE (FORM B)

Question 1 on general significance should include some provisions for considering the fact that natural succession is significantly changing some wetlands over periods as short as 20 years. We recommend that items 1.1 through 1.6 of this question be restricted to known, authorized wetland alterations. The user should not be asked to guess about possible future actions that may affect the significance of the wetland site.

In one sense, Form B is an open invitation to apply a wide range of societal considerations to wetland evaluation not handled earlier in the system. However, we believe that expansion of Form B to make it more comprehensive will strengthen it and eliminate the open ended aspect it now has. We recommend that the Form's use and interpretation be structured more along the lines of the keys in Form A, including interpretive guidance. The notion of "proportion" of responses is too vague. In some cases a single "yes" response should be enough reason to assign a "high" significance to a particular wetland. In other cases, a combination of positive responses might be required. In revising Form B, assessment methods from a wide range of disciplines should be employed, including the social sciences and humanities. Form B should include a notation that a condition could be encountered during the assessment that would come under the jurisdiction of an overriding legislative directive, like the Endangered Species Act.

IMPACT VECTORS (FORM C)

This form is specific to highway construction. If future versions of the FHWA system are written to enable other government agencies and construction interests to assess impact vectors, other versions of this form will have to be devised.

VALUE SUMMARY (FORM D)

When changes in the FHWA system are adopted, Form D will need to be revised accordingly.

SUMMARY

While the FHWA system is incomplete in certain respects (e.g., wildlife), it is adequate for evaluating functions of wetlands on a one time visit basis. It is also useful for early database construction in long term planning and for facilities development. The system is not adequate for cumulative impact assessment, mitigation planning, future planning, and long term regional planning because "rules of thumb" are not appropriate for these kinds of activities. Individual research projects are needed instead. The system also is not useful for species enhancement planning because it is too general, as opposed to the HEP and HES procedures.

In summary, we have examined the FHWA system from the view of the potential user. We find the concept sound. The framework is good, but incomplete in outline. Assuming that many of the 75 elements are a good first approximation of useful predictors, we urge that the system be field calibrated as soon as possible.

REFERENCES

Adamus, P.R. 1983. A method for wetland functional assessment. U.S. Dept. of Transportation Report FHWA-1P-82-83, Vol. I, 176 pp., Vol. II, 138 pp. Washington, DC.

HYDROLOGY PANEL

Virginia Carter (Co-Chairman), Thomas Winter (Co-Chairman), Richard Novitzki (Co-Chairman), Garrett Hollands, Terry Lejcher, Arnold O'Brien, Donald Siegel, Thomas Straw, Nancy Bartow (Recorder).

INTRODUCTION

The wetland functions addressed by the Hydrology Panel were: (1) ground water recharge; (2) ground water discharge; (3) flood storage and flood peak desynchronization; and (4) shoreline anchoring (stabilization). The Hydrology Panel recognized that the water quality function (e.g., nutrient cycling and sediment deposition) is also a hydrologic function of considerable importance; however, this function was handled by the Water Quality Panel.

The FHWA system is intended to be a rapid assessment method. It provides a list of eleven wetland functions; 75 "predictors" of wetland functional value; extensive documentation of the assumptions, references, and validity of each predictor in relation to the function being evaluated; a series of forms containing predictors; a series of keys for combining the responses to predictors; and a rating structure of high, moderate, or low, derived from the responses on the keys. The discussions of the Hydrology Panel and the specific recommendations below are primarily related to the predictors, evaluation keys, and supporting material for Form A.

It is the opinion of the Hydrology Panel that water is the primary and critical driving force underlying the creation and maintenance of wetlands and that a knowledge of wetland hydrology is basic to an understanding of all wetland functions. There has been little substantive work done on the hydrology of wetlands, and we lack the knowledge needed to evaluate hydrologic processes in wetlands without careful measurements. Continuing research has resulted in a questioning of many of the basic assumptions previously held by hydrologists, especially in the areas of ground water, generation of runoff, and storm peaks. Therefore, an evaluation based on an examination of recent literature may be misleading. Furthermore, hydrology, unlike some functions of wetlands, cannot be directly observed or easily sampled. Hydrologic processes must be carefully measured for a long enough period to ensure that the measurements are meaningful and that uncertainty or error limits can be included. Water budgets are very important, but underlying assumptions and inherent errors must be identified. The state-of-the-art in wetland hydrology is not such that we can make definitive statements about recharge, discharge, or evapotranspiration from maps or site visits. We cannot extrapolate from the results of a few comprehensive wetland hydrology studies to all wetlands because of the complexity and variety of the hydrologic systems involved. More research to provide an improved capability to quantify and describe basic processes, such as evapotranspiration, recharge, and discharge, would improve our capability to measure and assess wetland functions.

GENERAL OBSERVATIONS, RECOMMENDATIONS, AND SUGGESTED CHANGES IN KEYS AND PREDICTORS

Ground Water Recharge and Discharge

Ground water recharge and discharge are actually hydrologic processes that occur throughout the landscape. It is desirable to identify and quantify these processes because of their importance to water supply, aquifer replenishment, wetland occurrence, function, and maintenance, and so on. In terms of wetland value, both recharge and discharge are very important. Recharge replenishes the local or regional ground water system; the water becomes part of an aquifer used for irrigation, drinking water, or municipal use or may be discharged again to maintain other more or less valuable wetlands. Discharge creates and maintains wetlands, maintains streamflow, supports plant and animal populations, and provides water for multiple uses. A higher value for recharge than discharge is implied in the FHWA system; we feel that such a distinction is unjustified. Although wetlands are generally discharge areas, it is clear that: (1) some wetlands function primarily as recharge areas; (2) some function as a recharge or a discharge area, depending on head relationships and antecedent conditions; and (3) some wetlands recharge and discharge at the same time. All wetlands do one or the other, or both, if we consider evaporation and transpiration directly from the water table as being discharge processes. In most cases, long term monitoring will be required to determine the recharge or discharge function of a wetland.

Our panel unanimously recommends that recharge and discharge be recognized and considered as hydrologic processes of equal merit. Note the following definitions of recharge and discharge, provided by Freeze and Cherry (1979:194):

> Recharge. In a recharge area there is a component to the direction of groundwater flow near the surface that is downward. A recharge area can be defined as that portion of the drainage basin in which the net saturated flow of groundwater is directed away from the water table.
>
> Discharge. In a discharge area there is a component to the direction of groundwater flow near the surface that is upward. A discharge area can be defined as that portion of the drainage basin in which the net saturated flow of groundwater is directed toward the water table.

It is apparent that hydrologic processes are critical to the existance and maintenance of wetlands. It follows, then, that understanding the hydrologic processes in wetlands is critical to understanding all wetland functions (e.g., flood storage, sediment trapping, nutrient retention, and habitat). It appears, however, that the Adamus (1983) technique is inadequate to address the processes of recharge and discharge; therefore, we recommend that those predictors used only to assess the recharge and discharge processes (except Predictor 56) be dropped from subsequent revisions of the FHWA system.

Because the FHWA report is available to the public and may be applied prior to future revision, the following qualifications to the use of the Recharge and Discharge Keys contained in the document are provided:

1. Do not use the word "basin" to refer to the wetland plus adjacent deep water; basin implies drainage basin to the hydrologist and is not synonymous with wetland plus deep water.

2. It is not the function of the FHWA system to compare the uplands to the wetlands in terms of recharge or discharge processes, nor is it possible to do more than guess at this comparison without measurements of some type.

3. Effectiveness per unit area for recharge or discharge should use only Predictor 56, which should be rewritten as follows:

   Does the water table, as measured in piezometers constructed at the water table, slope away from the "wetland plus deep water" on most of its sides, with no downslope water table divide occurring in the immediate vicinity, and (or) is the depth to water progressively deeper in a cluster of piezometers drilled at the same location but to different depths?

In semiarid and arid regions where evaporation is greater than precipitation, and where there are low permeability surficial deposits, it is possible to map areas of discharge using indicator species (Lissey 1968, 1971). Further research might identify plant or chemical indicators of discharge in other areas.

Flood Storage and Flood Peak Desynchronization

The panel considers flood storage and flood peak desynchronization to be a legitimate function of wetlands. However, we are not sure that the predictors suggested by Adamus evaluate this function adequately.

Flood Storage Key. The following is a list of recommendations for altering the Flood Storage Key section. This list follows the order presented in the Key.

1. The panel recommends striking the sentence beginning "The key is probably not valid..." from the introduction.

2. Under HIGH effectiveness per unit area, part A, the panel believes that it was not clear what area of the "wetland plus deep water," relative to subwatershed (Predictor 8), makes a wetland more

valuable or less valuable for flood storage. It is, perhaps, the volume of the storage available that is critical, and this may be dependent on antecedent events (e.g., previous rainfall). While we agree that flood peak desynchronization may be more important in the upper part (topographically higher) of the drainage basin (Predictor 9), this function is dependent on the storm track relative to the basin size and shape, intensity of rainfall, and other factors. Wetlands in the lower reaches of a drainage basin generally serve as storage areas. However, under some circumstances, they may also desynchronize the flood peaks or produce various other effects. Flood storage may be valuable throughout a drainage basin. Stream order (Predictor 10) is not a consistent nor an accurate measure of flood storage and should not be used.

3. Under a. Effectiveness per unit area, delete A.

4. Under a. Effectiveness per unit area, all right as is, but the wording in Predictors 27 and 66 should be changed (see Flood Storage predictors).

5. Under a. Effectivness per unit area, part c.

    a. Change the wording of Predictor 2.

    b. Delete Predictor 22.5N and use Predictors 26.1, 26.2, and 26.5, plus a substrate predictor: "unsaturated, permeable sediments (possibly Predictor 65)".

    c. Delete Predictors 69.1Y and 70.1N.

    d. Change the wording of Predictors 35, 43, and 45.

    e. Add the predictor:

    Gradient of inflow streams exceeds gradient of the wetland.

6. Because LOW is the opposite of HIGH, delete parts IA, IB, and IIA and modify part IIB, with reference to the above comments.

7. The opportunity key (HIGH) appears to be satisfactory.

Flood Storage Predictors. The following comments and recommendations are offered for the Flood Storage predictors:

2. Constriction of the Basin. Constriction of an outlet cannot always be measured from maps. This predictor should read "total outlet capacity is less than total inlet capacity."

3. Shape of the Basin. This definition and use of "basin" is not acceptable to hydrologists.

5. Basin Surface Area. What is the justification for these numerical breaks?

6. Wetland Surface Area. What is the justification for these numerical breaks?

8. Basin Area to Drainage Area Ratio. See Section on Flood Storage Key, above.

9. Location in Watershed. See section on Flood Storage Key, above.

10. Stream Order. Delete this predictor.

14. Perched Condition. Use some word other than "perched", which means there is an unsaturated zone below the wetland. How about "located on a topographic high or divide"?

27. Flooding Duration and Extent. Delete "several weeks"; even retention for a day or several hours can desynchronize flood peaks. The important idea is that changes can occur in stages that are related to flood events. In the case of successive flood events, the wetland may aggravate the flood if the storage space is filled up and water remains when the next rainfall event occurs.

28. Artificial Water Level Fluctuations. Why four times a year?

29. Natural Water Level Fluctuations. Wetlands with large fluctuations in water level may be more important for flood storage than those with small water level fluctuations.

32. Flow Velocity. Reconsider the concept in this predictor. Flow velocity when? During the low probability event?

34. Water Depth (Minimum). Water depth is not as important as the amount of available storage (freeboard).

43. Sheet vs. Channel Flow. This should be more clearly written and contain better graphics (see diagrams from the Wisconsin adaptation of Adamus). The type of channel is critical (e.g., no obvious channel, single small channel, braided small channels, or large channel).

45. Gradient of Edge. The definition of gradient is not clear in this context. It should read "gradient of wetland perpendicular or parallel (specify which) to the flow is 5%."

56. Ground Water Measurements. See Recharge/Discharge.

66. Discharge Differential. This predictor should read:

Surface-water inflow during floods exceeds outflow (seasonal). This condition is dependent on antecedent events; therefore, more than one storm event should be measured.

Input hydrographs exhibit higher flood peaks than output hydrographs (such an assessment must compare actual flood peaks).

Shoreline Anchoring

In general, the panel: (1) recommends the use of "upland" in place of "fastland"; (2) considers the size and width limits to be extremely arbitrary and scale-dependent; (3) does not believe that large wetlands are always more effective than small wetlands in shoreline anchoring; and (4) is not convinced that woody vegetation is more effective at preventing erosion than emergent vegetation. We question why unconsolidated shores (beaches, bars, spits) are not considered in terms of their erosion protection function. Is "shoreline anchoring" the wrong word to use in this context? Actually, it is the plants or rocks that anchor shorelines, while wetlands prevent or slow erosion.

Shoreline Anchoring Key. The following recommendations and comments are offered for the Shoreline Anchoring Key.

1. Under Effectiveness per unit area, add "particularly during low probability events" to the introductory statement (after "erosive forces").
2. Revise I (HIGH) to read "There is dense vegetation or rubble along the shoreline" (Predictors 42 and 23).
3. Revise II (HIGH) to include peninsular Predictor 37.
4. Delete II (low).
5. Opportunity key appears to be all right, although our inspection was cursory.

Shoreline Anchoring Predictors. Recommendations and comments on Shoreline Anchoring predictors are as follows:

4. Fetch and Exposure. "Fetch" should read "Effective Fetch". This predictor needs to be reworked in consultation with the U.S. Soil Conservation Service and the U.S. Army Corps of Engineers.

35. Width. This is a matter of scale. We don't think the width limits are appropriate. A 1 ft strip might be important to a 2-ft wide stream.

37. Morphology of the Wetland, Relative to Basin. Put this predictor in the key.

42. Wetland's Open Water. We don't think this is relevant.

51. Plants: Anchoring Value. Is this necessary? Do we have sufficient information?

GENERAL COMMENTS

Considerable effort has been invested in the development of the Adamus (1983) system, and it serves as an excellent "straw man" or base from which to proceed. However, the Adamus model is a complex system that is difficult to use and to critically review in its present format. The Hydrology Panel believes that the justification for some of the predictors is not adequate and that the numerical limits or breaks are not solidly based on adequate study data. The references are not always correctly cited nor are they always appropriate, considering the inadequacy of the underlying database. Additionally, the text (Adamus 1983) could be reorganized and simplified and the graphics improved substantially. We also need to consider if we have identified all the important considerations in determining whether to preserve, alter, or destroy wetlands.

The rating system could be improved, possibly by using two levels (e.g., high and low) rather than three. We question whether a system in which 95% of wetlands fall into a "moderate" rating is really a useful system for making value judgements.

RESEARCH NEEDS

Underlying all of the functions of wetlands are the basic hydrologic processes (recharge, discharge, precipitation, evapotranspiration, and storage) that are part of the hydrologic cycle and are quantified as components of wetland water budgets. Very little is known about some of these processes in wetlands, and the quantification of fluxes is subject to large errors. The processes and functions that need additional research are discussed below:

Evapotranspiration

Water is removed from the land or water surface, the unsaturated zone, or the saturated zone by evapotranspiration (ET). Solar radiation, wind speed and turbulence, relative humidity, and available soil moisture affect the rate of ET. Measurement or estimation of actual ET (the true rate at which ET occurs) is done using water balance methods, such as lysimeters, water depletion measurements, and gas exchange chambers enclosing vegetation; micrometeorological methods, such as profiles, energy balance, or eddy fluctuation methods; or empirical methods that relate climatological measurements to evapotranspiration (Tanner 1967). Various formulae have been devised to estimate potential ET, the theoretical maximum rate at which ET will occur when there is no soil moisture deficiency (Penman 1948; Blaney and Criddle 1950; Thornthwaite and Mather 1957).

Direct measurement of ET is complicated and requires installation and maintenance of field instrumentation and relatively long term measurements.

Therefore, in most wetland studies, ET is estimated as a residual of the water budget equation (Winner and Simmons 1977), by ground water fluctuations when plants are rooted in a saturated medium (Burns 1978; Wang and Heinberg 1976), or by using an empirical formula to relate evaporation from a free water surface to potential ET and potential ET to actual ET (for example, Novitzki 1982). When ET is determined as the residual of the water budget equation, it is subject to all the errors of measurement and estimation of the remaining water budget components.

Evaporation from a free water surface is typically estimated using National Weather Service Class A evaporation pans (Farnsworth et al. 1982), and less often using mass transfer and energy budget methods. Winter (1981) states that the energy budget method is the most accurate; the error in annual estimates may be 10% or less (for a complete discussion of errors in measurements of evaporation, surface water, and ground water, see Winter 1981). The relationship between evaporation from a free water surface and wetland ET rates is subject to much disagreement. A number of studies indicate annual lake evaporation to be about 0.7 of pan evaporation (e.g., Kohler et al. 1959; Yonts et al. 1973), but the coefficient is dependent on climatic factors, and many wetlands do not have a free water surface or have one for only a part of the year.

ET losses from wetlands may vary by climate; species; and vegetation cover, density, and phenology. Definitive studies in comparative rates of ET are lacking. Estimates of ET from different types of wetland vegetation during the growing season range from 0.54 to 5.3 times that of pan evaporation (see references in Carter et al. 1978). Given the variety of techniques used to make ET measurements and the inadequacy of the experiments (Lugo et al. 1975), the estimate disparity is not surprising.

Surface Water

Surface water measurements of streams and lakes, including the continuous determination of water level and discharge, are routinely made to compute various flow characteristics, such as base flow, volume, and storage. Usually, stream velocity, discharge, and area are single-valued functions of water level, thereby making the determination of these characteristics relatively simple. Estimates of channeled surface flow may be within 5% percent (Winter 1981).

Runoff, the process by which precipitation makes its way into stream channels, can be estimated by any number of techniques, most of which find their philosophical foundation in the work of Robert Horton (1933, 1939, 1945). According to Horton, surface runoff occurs when rainfall rates exceed the infiltration capacity of the soil. Runoff is often estimated from determinations of rainfall intensity and the physical characteristics of the basin. For such approaches, wetlands are generally considered to be water storage areas and their effectiveness as such is modified by such factors as microtopography and vegetation characteristics. Within the last two decades, however, many researchers have questioned the applicability of Hortonian runoff processes in the humid regions of the U.S. (e.g., Freeze 1974; Dunne et al. 1975; Chorley 1978). The result of this research suggests that runoff may be produced from specific zones in the basin and that the flood peak may not result as much from overland runoff as from discharge from subsurface zones. In this view, wetlands are often seen as prime sources of runoff (e.g., Kirkby 1978), as opposed to runoff detention areas. It is clear, therefore, that the fundamental nature of the runoff process is not well understood and that it is difficult to make definitive statements regarding the role of various types of wetlands in runoff production or stormwater detention.

In addition to runoff processes, the geochemistry of surface water needs to be better understood in order to improve the assessment of water quality functions of wetlands.

Ground Water

The ground water component of the wetland water budget is difficult to measure. Observation wells are used to determine the areal configuration of the water table, and piezometers are used to determine the hydraulic potential at selected points in the ground water reservoir. Wells and piezometers used for ground water and nutrient studies must be properly placed in the flow system (Winter 1977, 1978, 1981). When the ground water component is calculated as the residual of the budget equation, there can be serious errors or misinterpretations of water and nutrient budgets because there usually is no information about the error inherent in the residual term. Errors in the estimates of precipitation, ET, and stream flow are not usually quantified, and overland flow is seldom considered as a separate term. All of the errors in these factors are included in the residual term, and estimates of ground water inflow or outflow made by interpretation of the residual can differ from independent estimates of ground water by more than 100% (Winter 1981).

Studies are needed to better define flow systems and to relate flow systems to geology and climate. In order to quantify the relationship between ground water and surface water, more information is needed on the geochemistry of ground water and organic and inorganic surficial deposits, as well as the hydraulic properties of wetland soils. Design and proper placement of instrumentation are other areas needing research.

In terms of integrated hydrologic processes in wetlands, attention should be given to system dynamics (seasonal and yearly fluxes of water and changes in water chemistry) and to paleohydrology (long term variability in wetland dynamics).

Specific Wetland Functions

There is unquestionably more research needed on the flood storage and peak desynchronization and the shoreline anchoring functions of wetlands. Some of these studies might be done in the type localities mentioned below, but others are needed in urban and suburban areas and in basins where flooding is a major concern. Assumptions based on wetland location in the drainage basin, wetland size, storage area, constriction of outlet, or similar factors need to be tested before adequate criteria (predictors) can be developed.

Approach to Research Needs

The hydrology panel recommends that long term research into basic hydrologic processes in wetlands be conducted at type localities throughout the country. These type localities should be chosen on the basis of climate, geology, and vegetation, and they should be typical wetlands where the results of studies will have transfer value to the regional area. Sites should be intensively instrumented to provide the best possible measurement of water budget components and to permit evaluation of costs and precision of alternative measurement methods. There should be careful documentation of methods and results.

These long term studies can be used to provide immediate and continuing guidance on the best ways to meet management needs for evaluation. Such studies should provide increasingly better answers to the following questions related to "rapid assessments":

(1) How often, where, and when should measurements be made?
(2) What are the costs of alternative assessment methods?
(3) What are the errors involved in measurements and how can they be minimized?
(4) What tools do we need for assessment and what tools are available?

In addition, carefully instrumented type localities are potential sites for the study of various wetland functions, such as sediment trapping and nutrient cycling. Good communication among wetland scientists is needed to make this approach properly work to provide the information that is needed.

Finally, the Hydrology Panel believes that a Nationwide wetland value assessment system may be impossible to develop and implement at this time; regional differences in wetlands need to be considered and incorporated. Basically, every wetland should be assumed to have a value; that is, a wetland performs one or more useful functions, unless it is proven otherwise. Limiting the value of wetlands to functions that are useful only to humans is short-sighted. Wetlands are an integral part of the hydrologic cycle. They are landscape elements that reflect the close connection or interface between ground water and surface water. Destruction of wetlands may alter hydrologic processes and change the hydrologic system. Such changes may be irreversible.

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WATER QUALITY PANEL

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INTRODUCTION

The water quality panel began with some assumptions and developed others in the course of discussions on the impact of wetlands on water quality. The panel began with the assumption that they would not become involved with considerations of mitigation and other highway-related items nor with wetland to wetland comparisons. Several other assumptions were developed during the course of the panel's work. The principal additional assumption was that the assessment should be a quick and short procedure, because detailed information would not be available in most cases. More involved decisions would require further procedures or a different level of assessment. It also became clear to the panel that the procedures became more streamlined and easier to understand when restricted to wetlands of a single classification or within a single ecoregion. Consequently, the assumption was developed, and a recommendation was made, that a certain degree of regionalization of the document should ultimately develop.

The assessment section of the procedure was of concern, leading to the assumption by the panel that societal significance is probably best handled on an agency by agency basis. Therefore, societal significance was excluded from consideration by this panel.

There are several different categories where the FHWA procedures can be streamlined, improved, and strengthened. Therefore, one of the main actions of the panel was to review and modify the procedures. The result was that the blocks in the box and arrow diagram described in the procedures section (Vol. II, Page 1) of the Federal Highway Administration (FHWA) document (Adamus 1983) were moved and altered by the panel. The product of the process, as now written, is a column of values for particular ecosystem functions. The panel felt that this was too specific and that a matrix of values would be a more appropriate outcome from the assessment procedure. These changes are significant, but they are not counter to the principles and procedures of the FHWA document.

The panel also believed that a third major water quality function of wetlands, the retention of anthropogenic substances (A.S.) should be added to the FHWA system, in addition to the nutrient and sediment trapping functions. Consequently, the group discussed the definition of such a function and the predictors for it.

There are presently three features of wetland values that are considered in the FHWA system: opportunity; effectiveness; and social significance. This panel felt that the first two of these value components were useful, but that the third (social significance) should probably be replaced by the ecosystem significance of that particular function. At a more detailed level, the original predictors of wetland water quality functions were modified, deleted in some cases, and some new predictors suggested. In view of the probable lengthiness of any field data gathering procedure that relates to seasonality and other cyclic behavior of wetlands, the panel felt that it would be best to collapse the time modifiers in the FHWA system and to retain the annual average predictor values.

The panel addressed the probable accuracy of the procedure as modified. In each of the value component categories, there are acknowledged imperfections, database gaps, and difficulties in acquiring the necessary information. The panel, therefore, believed that accuracy improved with the progression from the desk level to the detailed field level, but that great accuracy could not be expected from the method. Of course, field validation is needed to determine the predictive value of the FHWA procedure in the assessment of wetland impacts on water quality.

Finally, the panel addressed the items in the procedure that could be improved by research, what research was needed, and the necessary research variables.

GENERAL OBSERVATIONS AND RECOMMENDATIONS

General Comments

The purpose of assessing wetland functions and values is to establish the best estimates possible of the functions at various levels of significance. The panel believes that the FHWA system in its present form, can serve best as an "early warning system." As such, the FHWA procedure is quite cumbersome and elaborate. Therefore, it is probably necessary to streamline the procedure. Because of the complexity, the entire water quality structure cannot be considered. Therefore, some of water quality parameters are included in the form of predictors, or modifiers, in order to estimate the principal functions of nutrient retention, sediment retention, and retention of anthopogenic substances. In this class are species such as sulfate, chloride, humic substances, oxygen-related substances, and hydrogen ions. One wetland function, as defined in the FHWA system, is the retention of specific substance classes, but retention is but one term in a budget for those materials. The input, output, and generation of each class of material are important; in particular, the generation of wetland-related substances appears to have received too little attention. The scientific basis for the FHWA system is impressive, but the panel found several instances of incorrect interpretation of the literature, particularly in relation to their own publications. Frequently, the basis for a hypothesis or a predictor was found to be tenuous at best. Consequently, further effort is probably warranted to develop a firmer foundation and a more certain intepretation of the background literature in each predictor area.

The wetlands classification system of Cowardin et al. (1979) is stated as a prerequisite to the application of the FHWA assessment. This panel completely agrees and believes that the application of the wetlands classification procedure should be moved to a lead position in the assessment process. There are so many commonalities between principal wetland types that it may be desireable to develop subsets of predictors that are relevent to each major wetland type. A related early subdivision of the National scenario is the regionalization of the assessment procedure. This panel believes that regionalization is necessary and, consequently, added it to the assumptions under which we attempted our critique of the FHWA system.

The data sources on which the FHWA assessment is based are critical to the success of the procedure. The panel could not identify a particular threshold where lack of data would render the procedure meaningless; however, several key data sources were repeatedly referred to as being useful. These data sources include topographic maps, wetlands inventory maps, soil maps, and other recognized sources of wetland information. The panel recommends that, in all cases, the database include at least a reconnaissance field visit. It should also include contacts with local people who are knowledgable about the condition and functions of the wetlands and watershed in question. These contacts could be especially useful in determining the history and, perhaps, the seasonal changes of the site in question.

The outcome of the assessment procedure, either the original or a modification, was examined by the panel and no clear indication of bias was found. That is, it did not appear that most wetlands would be ranked low or high in the water quality functions. Arguments can be presented for either ranking. Therefore, field validation is needed to ascertain whether or not bias exists.

Procedural Modifications

The version of the FHWA procedure that was considered by this panel is illustrated in Figure 1. The alteration proposed by the panel is shown in Figure 2. The modification of the overall FHWA approach was not large. The added block, namely ecosystem significance, is discussed in a later section. The block labeled human significance is still in the anticipated overall assessment process, but is not included in the early warning system assessment. The first block in Figure 2 contains the two recommended up front activities that are not clearly indicated in the FHWA document: regionalization and wetlands classification. At this point, a "red flag" may obviate the need for a complete assessment. For example, the wetland being analyzed might be the last wetland of a given type in a given region. The early subdivision by region and wetland type does not have large implications for the predictors/functional value/component analysis; however, it does have large implications for the ultimate form of the document and its applicablility.

The opportunity and effectiveness assessment functions are unchanged. The ecosystem significance block has been added as a third parallel

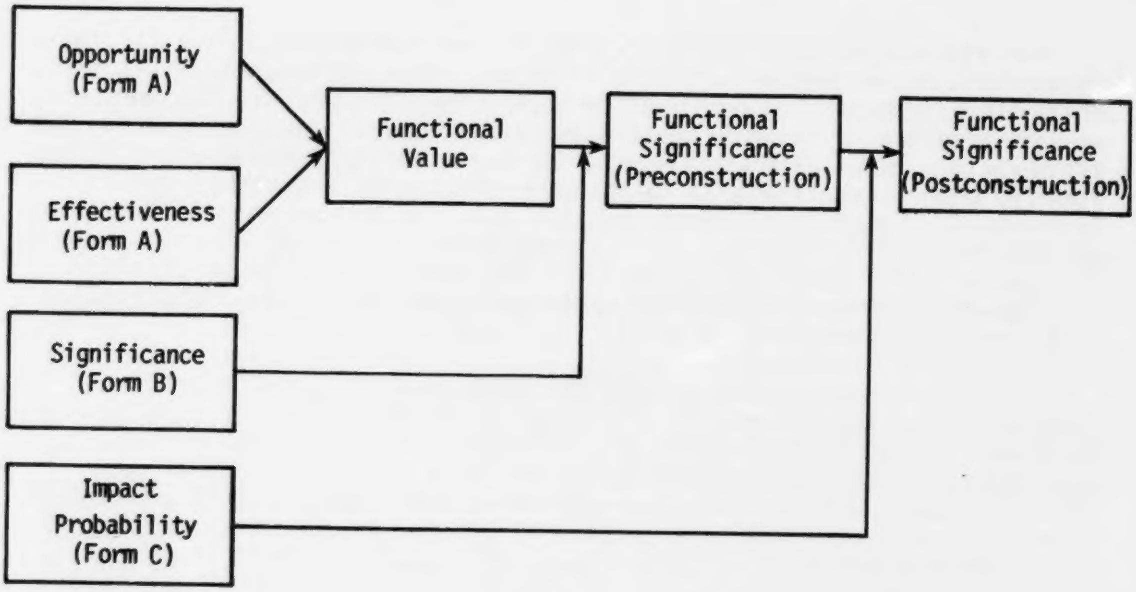
Opportunity (Form A)
Effectiveness (Form A)
Significance (Form B)
Impact Probability (Form C)
Functional Value
Functional Significance (Preconstruction)
Functional Significance (Postconstruction)

Figure 1. FHWA relationships of concepts that determine wetland value.

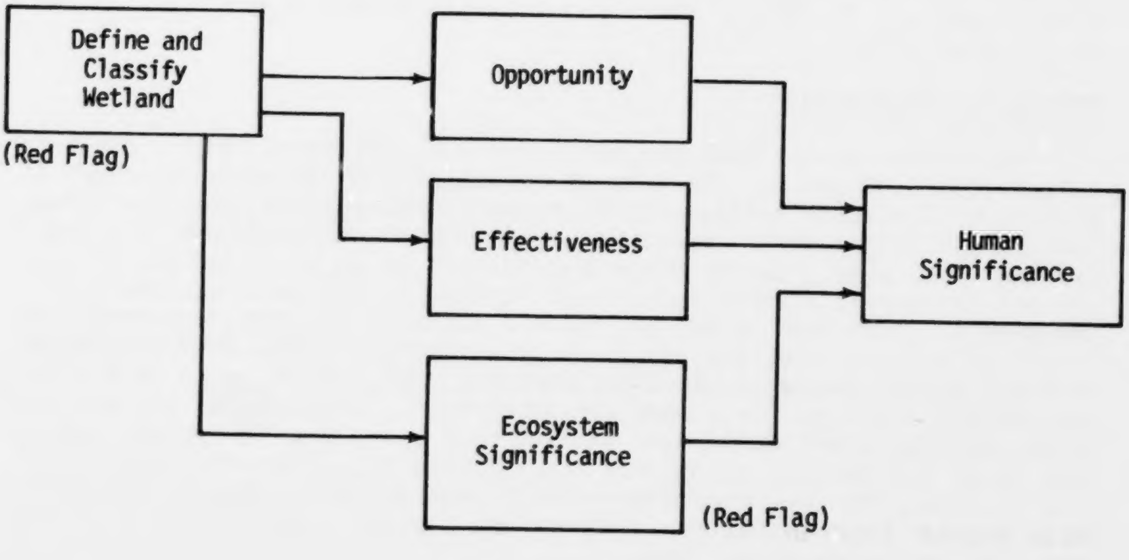
Define and Classify Wetland
(Red Flag)
Opportunity
Effectiveness
Ecosystem Significance
(Red Flag)
Human Significance

Figure 2. Recommended changes by panel in the relationship of concepts that determine wetland value.

activity in the assessment, based on the assumption that the significance of each wetland attribute and function to the surrounding ecosystem needs to be understood. The result of the three component analysis is a matrix of values (Table 1.). In the FHWA document, this analysis is followed by a determination of the social or human significance value of the particular wetland function. This panel believes that the desire for generality, i.e., the applicability to the problems of more than one sector of our society, make it very difficult to develop a general list of significance factors that could be applied Nationwide and fit the needs of all agencies. The significance section of the FHWA document emphasizes trade-offs and should be replaced by an agency-specific list of factors. It is unlikely that any one person can be responsible for both the ecosystem level and the societal significance function analyses with balanced emphasis.

Table 1. An example of water quality function ratings.

Function/Value Component	Opportunity	Effectiveness	Ecosystem Significance
Sediment Trap	H	H	H
Nutrient Trap	M	M	L
Anthropogenic Substances Trap	L	L	L

Product Modification

The FHWA system combines the opportunity and effectiveness value components into a single measure, called the functional value. The functional value is then modified by a societal significance rating to produce a combined functional significance. This panel believes that these combinations are too arbitrary and condensed. The panel, therefore, recommends that the columns on Form D (which is the main product of the assessment) for functional rating and functional significance be deleted and that the last column be retitled ecosystem significance (Table 1). It then becomes the responsibility of the decisionmaker or regulator to make use of the portions of the final product that apply to the relevant societal problems.

The current FHWA system of low, medium, and high rankings for each functional value is acceptable to the panel. Greater detail in ranking is probably not warranted at this level of assessment.

Water Quality Functions

The panel endorses the two water quality functions proposed by the FHWA document: nutrient retention and sediment retention. In addition, the panel recommends that a third function be added, the retention of anthropogenic substances. These materials fall into three general categories: heavy metals; toxic chemicals; and pathogens. We believe that the need to consider this function is valid because of the increasing impacts of human activities on wetlands. There is significant and growing literature in this particular area, and no assessment should ignore this function, even though it may be somewhat unpleasant to contemplate the consequences of these types of materials in wetlands.

There was not enough time for a thorough development of a predictor list to deal effectively with anthropogenic substances. The following new predictors were the most obvious:

1. This predictor would result in a positive or high ranking of the sediment opportunity and effectiveness value components. The basis for this statement is the well documented connection between particulate materials and both toxic chemicals and heavy metals. There is a strong tendency for metals and chemicals to adsorb to particulates, and travel with them, so that the hypotheses that relate to sedimentation have companion hypotheses with similar relevance to retention of A.S.

2. This new predictor would be a determination of activities in the watershed that generate A.S. The list is long and fairly obvious: mine dumps; garbage dumps; mine tailing piles; plating plants; and other manufacturing plants.

   All of these sources have the potential for discharging metals and chemicals into surface water and ultimately finding their way to a wetland.

3. This predictor would look at the existence of agricultural practices in the watershed that result in agricultural chemicals, such as pesticides, reaching the wetland.

4. This predictor would indicate the existence of natural sources of heavy metals and toxic chemicals within the watershed or wetland. The initial reconnaissance might provide some indication of their sources within the watershed or wetland.

5. This new predictor would entail detailed input and output sampling for selected A.S. materials.

6. The turnover time that is related to A.S., as well as several other functions, would be the sixth new predictor.

In addition to these new predictors for A.S., many of the original 75 predictors are applicable to a potential key to determine the retention effectiveness and opportunity for A.S. materials. In particular, the following list was identified by the panel:

1. Contiguity.
9. Location in Watershed.
22. Vegetation Form.
23. Substrate Type.
26, 27, 28, and 29. Hydroperiod, Flooding, and Waterlevel Fluctuations.
36. Oxygenation of Sediments.

39. Basin Alterations.
43. Sheet vs Channel Flow.

New Value Component: Ecosystem Significance

The previously introduced concept of a third value component was developed, to the extent possible, in the given time. Several factors were determined to be useful in the assessment of ecosystem significance. The cumulative impacts of sediments, nutrients, and A.S. on the condition and function of the wetland are important. The accumulation of excessive amounts of any of these materials can have a deleterious effect on the wetland. Some projection needs to be made of this significance variable at the assessment level. The wetland ecosystem exists in interrelationship with surrounding land forms and has particularly important implications for downstream areas. The FHWA system implies the societal effects of downstream human activites. In the same way, the ecosystem significance component should include factors relating to ecosystem function in the same locations. Thus, if the objective is to preserve a recreational water body downstream from large nutrient input that might lead to lower water quality there, the intercepting wetland should have a high significance value for nutrient retention.

Ecosystem stability and resilience are significant to all three of the water quality functions. Included in this category are questions related to thresholds for wetland loading of the three groups of water-borne substances. Questions related to decreases in the number or size of the wetlands in the system being evaluated also are included; this is important in a number of contexts.

Another question category would determine the significance of functions with respect to the stages of the normal cycles of the wetland being evaluated; thus, there might be more significance for a particular function during the wet season than the dry season, in winter or summer, or during different stages of the normal evolution of the wetland system. The next question category determines the significance of a given function as it relates to the condition of a wetland. A wetland that is retaining nutrients is likely to present a more eutrophic condition; this is significant when we consider the aesthetic values of a wetland. Another question category identified by the panel is the management potential for an improvement in ecosystem functions. The nutrient, sediment, and A.S. retention of a wetland can, in some cases, be greatly improved through proper management of the water, particularly water level manipulations. The potential for enhancing the effectiveness of a wetland functioning in an area should be determined. It is possible that a simple and inexpensive modification of a wetland basin, such as a small dam or other simple water control structure, could greatly improve the retention capability and, therefore, the overall rating of a wetland. The maximum potential nutrient trapping efficiency of a wetland, as well as its actual efficiency, should be considered in an assessment of this type. The assessment of the maximum potential efficiency is only possible and meaningful in some wetland types. A last significance question category involves the effect of consumptive uses on water quality functions. For example, peat mining might be significant in terms of the retention of heavy metals.

The above significance factors are not all inclusive; however, the panel believes that these categories of significance factors are more appropriate to the type of assessment that is being conducted than the agency or societal significance factors currently in the FHWA system.

Summary of Recommendations

The water quality panel believes that a modified version of the FHWA assessment procedure can be successfully used. Certain modifications are desirable, namely the regionalization of the procedure; the separation of predictors by wetland classification; and the alteration of the functions, value components, predictors and time modifiers. The product of an assessment should be a larger array of value ratings than is currently indicated. It is probably not possible to include anything more than annual average behavior in the rating. We believe that specialized questions, requiring detailed data, should not be included. If the assessment procedure is to be used by a variety of agencies, it is probably desirable to make the social significance factors agency-specific. There should be an opportunity for certain unique circumstances to result in the assessment being abandoned at any stage. Questions of accuracy in detail can only be answered by field validation. The water quality panel recommends that the system be tested in a variety of intensively studied wetland locations and contexts to validate its conclusions and predictions.

RESEARCH NEEDS

It is clear that more research is needed in relation to all of the water quality functions. However, it is this research need that caused the panel to operate under the assumption that only a "quick and dirty" assessment is possible with a high probability of a successful result. There are areas that need further research in order to improve the accuracy of the FHWA assessment procedure. The first area, of most significance, includes water and sediment processes and all of the ecosystem significance factors previously identified. Sediment processes have been researched to a large extent in aquatic systems, but very little research has been done on the details of sediment processes in wetlands. This research need does not preclude a certain degree of confidence in the assessment procedure at present, because adequate input-output information is available. Water budgets and flow processes need to be better understood in order to predict nutrient retention. Ecosystem significance factors, such as threshold loadings, have not been studied and are important to the assessment process. It is clear, from a small number of studies on a few wetland types, that loading limits for nutrient retention do exist and that, when these limits are exceeded, the ability of the wetland to retain nutrients ceases.

Secondary, but also important, research areas related to water quality functions involve the generation and transformation of the water-born substances under consideration. This, in many cases, involves further knowledge of the microbiology of the wetland systems. Even the physical and chemical processes involved in the transformation and modification of anthropogenic substances are not understood. The generation of detritus and the closely related processes of nutrient retention and heavy metal retention are poorly understood. The assessment procedure can be operational without these research projects, but the predictive value of the procedures will be significantly improved when this information is available.

ANALYSIS OF KEYS AND PREDICTORS

The following outline reflects the evaluation by the water quality panel.

1. Contiguity. This is an important predictor and should be retained in its present form.

2. Restriction of the Basin. This predictor is of dubious value. More direct measures, such as waterflow area, might be more appropriate.

3. Shape of the Basin. This predictor is of little value.

4. Fetch and Exposure. This predictor is appropriate in its present form.

5 and 6. Basin Surface Area and Wetland Surface Area, respectively. These predictors are not in the sediment and nutrient keys, which seems appropriate.

7 and 8. Basin Area to Watershed Area Ratio and Basin Area to Drainage Area Ratio, respectively. These predictors are of dubious value.

9 and 10. Location in Watershed and Stream Order, respectively. These predictors are accepted by the panel in principle. However, location in the watershed is the more important of the two predictors and stream order could be dropped.

11. Gradient of Subwatershed. This predictor is acceptable on a regional basis.

12 and 13. Gradient of Tributaries and Gradient of Basin, respectively. These predictors are of dubious value.

14. Perched Condition. This predictor is of little value.

15. Land Cover of Watershed. This is one of the best predictors of the opportunity for the wetland to receive materials from the subwatershed.

16. Land Cover Trends. This predictor is a good indicator of the types of materials that may arrive in the wetland.

17. Soils of Subwatershed. This predictor was given a high rating.

18, 19, and 20. Lithologic Diversity, Delta Environment, and Evaporation-Precipitation Balance, respectively. We recommend that the present status of these predictors be retained.

21. Wetland System. This predictor should be given the "front-end" position as a determinant for the entire set of predictors.

The first 21 Predictors in the FHWA system (Group A) are intended to be determined from an office environment. The panel concurs that this is a reasonable expectation and that some meaningful information can be determined in this way. We referred to this type of predictor as a level 1 predictor.

In contrast, group B (Predictors 22 through 51) in the FHWA system include questions that usually require field data to answer. The panel decided that this meant one reconnaissance trip to obtain field data, rather than more extensive investigation. The panel designated these predictors as level 2 predictors.

22. Vegetation Form. Three categories might be adequate for this predictor: the existence of woody plant material (both trees and shrubs); the existence of other persistent plants; and the existence of other vegetation. Persistent plants are those with the capability of retaining some standing dead material from year to year. The vegetation form designations are important with respect to nutrient retention because they predict the permanency of storage in living biomass and the rate of litter decay.

23. Substrate Type. This predictor is believed to be of extreme importance. (Basic distinction: water quality function relates to whether the sediments are organic or inorganic.)

24. Salinity and Conductivity. The panel favored the retention of this predictor for regionally selected cases; for example, with evaporating wetlands in the West and with estuarine systems.

25, 26, and 27. pH, Hydroperiod, and Flooding Duration and Extent, respectively. These predictors should be retained.

28 and 29. Artificial Water Level Fluctuations and Natural Water Level Fluctuations, respectively. These predictors are important, but could be combined into a single predictor.

30. Tidal Range. This predictor is clearly dependent on wetland classification and was believed to be of dubious value in predicting water quality functions.

31. Scouring. This predictor is appropriate as stated.

32, 33, and 34. Flow Velocity, Water Depth (Maximum), and Water Depth (Minimum), respectively. These predictors should be replaced by a new predictor, which we designated as new predictor 6: the turnover time determined on the wetland water sheet. Turnover time could be defined as the amount of water in the wetland divided by the outflow from the wetland.

35 and 36. Width and Oxygenation of Sediments, respectively. These predictors should be added to the keys for nutrient and sediment retention. In addition, the panel believes that an attempt should

be made to incorporate Predictor 60, Water Quality Correlates, into a 36A, an oxygen-related Predictor.

37. Morphology of Wetland. This predictor is appropriate for estuarine wetlands.

38. Flow Blockage. This is not a terribly important predictor, but the panel recommends retention in the system.

39 and 40. Basin Alterations and Pool-Riffle Ratio, respectively. These predictors should be retained in their present form.

41. Basin's Vegetation Density. This predictor is of dubious value, but perhaps worth retaining for palustrine systems.

42. Wetland's Vegetation Density. This predictor is of little importance in the palustrine system, but it might be of some importance in the other wetland systems.

43. Sheet vs. Channel Flow. This predictor should be retained in its present form.

44. Wetland-water Edge. This predictor could be deleted.

45, 46, and 47. Gradient of Edge, Shoreline Vegetation Density, and Shoreline Soils, respectively. These predictors are important indicators of the potential for sediments to reach wetlands. However, these three predictors might be condensed through the use of the universal soil loss equation applied to the margins of the wetland.

48. Disturbance. This predictor should be retained in its present form.

49, 50, and 51. Plants, Form Richness; Plants, Waterfowl Value; and Plants, Anchoring Value, respectively. The panel agrees with the omission of these predictors in water quality function keys.

In addition to the present predictors, the panel felt that some new predictors could be added to the FHWA list and some existing predictors should be modified. A new predictor could be added dealing with the presence of potential sources of airborne materials that might carry any of the three types of material (nutrients, sediments, or A.S.) to the wetland (in addition to water transport). Another new predictor could be added pertaining to climatological factors, such as snow depths and frost depths, that might be of use in determining the fraction of the year in which certain processes might occur. Finally, a new predictor could be added relating to the field identification of major sinks and sources of materials in the vicinity of the wetland. Although other predictors attempt to assess this through indirect questions, direct evidence of how some of these materials reach the wetland is also useful. For example, the existence of a sewage treatment plant that discharges to the watershed or the wetland should be given high significance in a list of predictors.

The next section of the FHWA document (Group C) deals with predictors (52 through 68) that require detailed data. The panel believes that the level of detail of these predictors, designated as level 3, should be reduced considerably. We recommend that these predictors be dropped in their present form, with the exception of Predictor 60, which should be included with the level 2 oxygenation questions (as previously noted). As a trade-off, the panel recommends the inclusion of some new predictors of a general nature. These predictors would deal with input and output measurements of water flow and sediment, nutrients, or A.S. content at several times during a year or during a turnover time, whichever is longer. Water flows would be required as companion measurements. Measurements would be required several times during a year, spanning the seasons and other annual cycles, or during the residence time or turnover time of the wetland. Two turnover times were believed to be minimal for this purpose.

The fourth category of FHWA predictors (69 through 75) is group D, derived data. These predictors are related to the answers to the other functional assessments and most of them are either repetitive or tenuous. The panel recommends that only Predictor 74 be retained as it appears in the FHWA document and the rest be deleted.

The FHWA procedure calls for a certain amount of modification and amplification based on wet and dry seasons and annual attribute averages and on a determination of seasonal and long term behavior. The panel believes that the databases needed to make these distinctions are unlikely to become available in the course of these assessments. Consequently, answering questions that require details within annual cycles would require data gathering efforts that are beyond the scope of a general purpose assessment. This type of detailed question would probably require a tailored research program in order to provide the decision factors required in a specific instance. Therefore, the panel recommends that the assessment process involve answers only for annual average predictors and annual average values for the water quality functions. We realize that this restricts the assessment to long term generalities, but that is the highest expectation possible for such a general purpose assessment.

The FHWA procedure is based, to a large extent, on circumstantial evidence. Therefore, the panel attempted to estimate the degree to which accurate results would be obtained from an assessment depending on the level of data acquisition. For level 1 predictors (determined in the office), there would be medium accuracy for opportunity and low accuracy for effectiveness. When the reconnaissance level 2 predictors are added, the accuracy for both opportunity and effectiveness would be slightly better. If the time and expense for level 3 measurements can be spared, the FHWA procedure should produce highly accurate results for opportunity and results with medium accuracy for effectiveness. No accuracy estimates were made for the new significance value component. Field validation is obviously needed to validate the estimated accuracy of the FHWA procedure.

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FOOD CHAIN PANEL

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INTRODUCTION

It is the unanimous view of this panel, after a detailed review of the FHWA wetland assessment method, that the portion of the assessment dealing with food chain support and nutrient cycling should not be used in its present form. The panel's conclusion is based on the fundamental fact that the current understanding of wetlands ecology is not adequate to support such a specific, quasiquantitative evaluation procedure. We do not agree that the literature cited in the FHWA report (Adamus 1983) adequately documents or justifies the assertions made regarding the relative values of wetlands for food chain support and nutrient cycling. However, the panel recognizes the fact that decisions regarding the relative values of wetlands will continue to be made. The uncomfortable and humbling truth is that, to the degree that these decisions are based on considerations of the food chain, nutrient cycling, and numerous other values, they are largely subjective impressions with little empirical support at this time. To obscure this fact by invoking a complex and seemingly sophisticated scientific assessment procedure will not serve either decisionmakers or the public. On the positive side, however, the exercise of attempting to develop such a procedure has emphasized the importance of considering many dimensions of wetlands ecology. It has documented the pressing importance of obtaining new kinds of information about wetlands. It is probably not productive to pursue the kind of assessment protocol for food chain support attempted in the FHWA study until new research initiatives, such as those set out below, begin to provide the needed information.

GENERAL OBSERVATIONS AND RECOMMENDATIONS

It is necessary to be aware of the assumptions or hypotheses on which the evaluation is based, in order to understand our critique. These assumptions are listed in detail in Volume II, pages 69 and 71, of the FHWA report (Adamus 1983). Briefly, these assumptions are:

1. Wetlands have significantly greater net primary productivity than terrestrial or aquatic ecosystems;

2. There is a greater transport of food from wetlands to aquatic consumers than from other ecosystems, and greater transport of food from those wetlands that have better downstream transport mechanisms (flushing) than those that lack flushing.

The mechanism for evaluating food chain support is to use predictors that appear to correlate with primary productivity (or to use primary productivity itself), flushing and transport of the organic matter and nutrients, and more and faster decomposition results in greater food chain support. The panel either disagrees with these assumptions or believes that there is not enough information to generalize about them for the purpose of ranking one wetland above or below another wetland.

Our acceptance of four of the predictors and suggested modification of nine of the predictors should not be interpreted as revisions that would lead to a valid assessment of food chain support. What the panel is recommending is a completely new effort, outlined below, that is a more lengthy and detailed endeavor than simply revising the present FHWA document. The food chain section of the present document is based on invalid assumptions and misinterpretations of existing information. Until these deficiencies are corrected with better information and scientifically sound assumptions, food chain support values of wetlands must be assessed by other procedures. These other procedures might take the form of indicators that food chain functions exist and be based on HEP or HES procedures or observations by experienced wildlife and fisheries ecologists. However, the panel did not formally discuss or evaluate alternate procedures for evaluating this wetland function. The fact that the FHWA document has been found to be an inadequate and unacceptable procedure for the evaluation of food chain support (i.e., starting from the base of the food chain) does not mean that wetlands are any less valuable for this function.

The panel has learned an important lesson from the evaluation of the food chain support section of the FWHA document. In our attempt to seek a wetland evaluation method, the FWHA attempt could be considered analogous to a hypothesis. The panel has rejected this "hypothesis". Therefore, it is incumbent on us to provide direction toward the development of an alternate hypothesis (or method) to be tested. It is the opinion of the panel that more progress is needed in understanding food chains before an alternate hypothesis can be adequately developed. Therefore, we recommend a three step program toward developing information on which an initiative on food chain evaluation can be based.

1. Literature synthesis: Rather than a literature "review", this synthesis should be a very selective and intentional effort to document what is and is not known about food chains. The synthesis should address hypotheses that have as their components the following:

    a. the relationship of primary productivity to fish and wildlife production;

    b. the nature of coupling between wetland and open water areas of a basin; and

    c. the quality of food available and its value in food chains.

    Auxiliary factors that may be important regulators or modifiers of the relationships hypothesized above should also be evaluated.

These include, but are not limited to, the importance of structural features, morphometric characteristics, flushing, and interspersion.

2. Peer review: The literature synthesis should receive a comprehensive review by peers who are compensated for their efforts. This should be followed by a workshop of researchers in the field of wetland food chain support with expertise with a variety of wetland types. The workshop attendees would formulate the hypotheses to be tested for applicability to a broad spectrum of wetland types.

3. Research effort: The focus of the research would be testing the hypotheses that resulted from the literature synthesis and workshop. This step is discussed in detail in the following section.

RESEARCH NEEDS

The research effort should have a strong experimental component that takes the form of manipulating the key variables that affect food chain support. Ecosystem evaluations, including this one, reflect the maturity and evolution of the related field science. Hypotheses, data, and information summarization develop from the application of available time, money, and expertise. Consequently, a "best effort" evaluation tool may at this time incorporate untested hypotheses, hidden assumptions, and little data in the rationale for a particular ranking. This is not to say that information is not available, but that critical experiments and logic are absent. The surfeit of assumptions and dearth of appropriate analyses are conspicuous throughout the FHWA document. It is commendable that this document clearly identifies and states the hypotheses for each predictor. The lack of documentation to support conclusions or to test hypotheses reflect a preoccupation with descriptive, rather than experimental, approaches; with examining ecosystem standing stocks rather than turnover; and with restrictive studies of wetland parts, especially of large consumers, rather than studies of how the system "works" to produce large, rare consumers. It is the nature of our young science that descriptive work must often preceed experimentation. The very expression of the hypotheses in the FHWA document reflects the need for more explicit experimentation in food chain dynamics. Few of the hypotheses mentioned have been directly tested. Instead, evidence is given by inference and reference to other related, but also unproven, assumptions.

The panel's recommendations for a better evaluation procedure are based on the belief that explicit testing of hypotheses is the best long term opportunity to improve the present analysis. The method selected to test the hypotheses is, perhaps, as important as selecting the questions to be addressed. The panel believes that the following attributes would contribute to meaningful progress in the research effort:

a. Team approach. The fields of expertise required to study wetlands includes hydrology, microbiology, nutrient cycling, succession, and many others. The economies of scale may mean that several hypotheses can be addressed simultaneously by a number of scientists representing several disciplines.

b. Long term research sampling. Experience with a variety of ecosystems has demonstrated the need for long term data collection efforts. For example, food chain dynamics are notorious for their susceptibility to climatic events. In addition, ecosystems are held together by a disjointed (in time and space) coupling of parts. The different responses by ecosystem parts over time are often out of phase with each other simply because of differences in growth rate, doubling rate, integration, timing, and other factors. Long term experience and monitoring are valuable, irreplacable requirements for addressing certain hypotheses about wetland functions.

c. Standardization. Methods vary with changing needs and perspectives. Given the general lack of data currently available, standardization of methods to the degree possible should be encouraged. A review of the methods commonly used and the development of agency awareness of problems with these methods should be developed by review panels to foster standardization where feasible and appropriate.

d. Comparative research. Determining the variation among and within wetland ecosystems is an implicit requirement if ranking is to be accomplished with precision and accuracy. Questions that need to be answered include: What is a typical wetland? Are the few wetlands studied representative? Are the results from one or two studies applicable to other wetlands with a similar community structure? A few simple comparisons of wetlands spread wisely over wetland types would be valuable.

Specific hypotheses to be tested should focus on the assumption that food chain support is primarily related to: (1) the level of primary production; (2) the quality and quantity of the detritus that is produced during decomposition; and (3) the degree of coupling between the wetland and the adjacent open water area. There are, of course, other important variables. The panel believes, however, that the additional variables cannot be adequately tested until the first of three basic assumptions are critically evaluated. We propose that research activities be directed to focus on three general research questions: (1) What is the relationship between the amount of primary production that occurs in a wetland and the amount of secondary production within the wetland and in the wetland basin?; (2) What is the relationship between the amount of primary production that occurs in a wetland and the quality and quantity of the organic matter that is available to support secondary producers within the wetland and in the wetland basin?; and (3) What are the food chain relationships between wetlands and adjoining (coupled) open water areas, and how does the coupling affect food chain relationships within the wetland basin?

ANALYSIS OF KEYS AND PREDICTORS

The Food Chain Panel discussed each predictor that was utilized specifically in the food chain key. These predictors are listed in Table 1, along with rankings from highest (1) to lowest (4). Because the panel had serious reservations about the value of many of the predictors, no attempt was made to assess whether or not the results of a particular evaluation would be properly interpreted for overall ranking of function (high, moderate, or low) in the food chain key (Adamus 1983: Vol. II, pp. 69-72).

Thirty-one of the 75 predictors used in the FHWA system were used in the Food Chain Key. The panel rejected 18 of these 31 predictors because they were of insufficient value to justify their use in assessing or ranking food chain support. Nine other predictors require modification in order to be acceptable for use. The remaining four predictors were considered acceptable; however, as a group, they are of little value in food chain assessment.

The extent and quality of documentation and the uncertainty about the assumptions for predictions are the two fundamental reasons that predictors were either rejected or judged to require modification. In many cases, this is because there is a fundamental dearth of knowledge about how food chains function. Adamus admits that the Food Chain Key is probably the least reliable of the evaluation keys. Although nearly 90% of the predictors were rejected by the panel or required modification, this should not be interpreted as meaning that food chain support is a trivial or even questionable function of most wetlands. On the contrary, this is possibly one of the strongest and most attractive attributes of many wetlands. The fact that so little information is available to document the predictors of food chain support may be another indication of how poorly the relationship between primary and secondary productivity is understood.

The following major reasons, with examples, indicate why the panel either rejected or suggested modification of predictors. Specific comments on each predictor are included later in this discussion.

1. Inadequate documentation. Many of the references cited to support the rationale for the hypotheses are generic in nature, but applied to specific processes (e.g., Darnell et al. 1976). In addition, many of the references are inappropriately cited (e.g., Gucinski 1978 - Predictor 44; Chabreck 1981 - Predictor 2),and many are misquoted (e.g., Klopatek 1978, Predictor 22 - Vegetation Form under F, nutrient retention). Overall, the amount of misquoted literature and inappropriate literature citations appears to be sizable. In addition, the misspelling of names, incorrect dates, and uncited references make the references difficult to verify.

2. The validity of the assumptions. Questions about the validity of the assumptions was one of the primary reasons for rejecting or modifying so many predictors. Many of the assumptions were based on data for estuarine or freshwater

Table 1. Ranking of wetland characteristics by their hypothesized importance to food chains (After Adamus 1983: Vol. II)

Wetland characteristics	1 Highest	2	3	4 Lowest	No. of References[a]
1.Contiguity	outlet & inlet	outlet only	no outlet		1
2.Constriction of basin's outlet	not constricted	constricted			4
3.Shape of basin	smooth	irregular or sinuous			0
4.Fetch & exposure	sheltered	unsheltered			2
13.Gradient of basin	steep	gradual			0
15.Land cover of subwatershed:	cropland or grazed	forested scrub-scrub,ungrazed grassland ----------developed-------- ----------barren-----------			0
22.Vegetation form	emergent aquatic bed	scrub-shrub	forested	moss/lichen	2
23.Substrate type	-----------organic-------- -------------mud----------		---rubble-sand/cobble-- ----bedrock, gravel---		2
24.Salinity and conductivity	fresh	mixosaline	eusaline	hypersaline	8
25.pH	circumneutral	not circumneutral			5

Table 1. Continued

Wetland characteristics	1 Highest	2	3	4 Lowest	No. of References[a]
26.Hydroperiod	regularly flooded tidal, seasonal flooded tidal	irregular exposed tidal, irregular flooded nontidal intermit-tently non-tidal	semi permanently flooded non-tidal, intermit-tently exposed non-tidal	permanently flooded nontidal saturated nontidal	8
	-----------artificially flooded nontidal----------------				
27.Flooding duration and extent	great	not great		See Predictor #26	
28.Artificial water level fluctuations	small, infrequent gradual	large, frequently sudden			1
29.Natural water level fluctuations	flashy	not flashy			1
30.Tidal range	great	slight			2
31.Scouring	moderate or unknown severe and known			See Predictor #32	
32.Flow velocity	moderate	slow or very rapid			8

Table 1. Continued.

Wetland characteristics	1 Highest	2	3	4 Lowest	No. of References[a]
33.Water depth maximum/minium	shallow	deep			0
36.Oxygenation of sediments	O_2 stress				0
41.Basin's vegetation density	neither sparse or extremely dense	very sparse or extremely dense			1
43.Sheet vs channel flow	sheet	channel			0
44.Wetland-water edge	irregu-larity shaped, good interspersion	smooth or poor interspersion		See Predictor #32	
45.Gradient of edge	steep	gentle			0
49.Plants form richness	diverse forms	monotypic			2
52.Plant productivity	high	low			0
53.Invertebrate density: freshwater/ tidal flat					

Table 1. Concluded.

Wetland characteristics	1 Highest	2	3	4 Lowest	No. of References[a]
57.Suspended solids	moderate	low	high		12
58.Alkalinity	high	low			1
59.Eutrophic condition	moderate or high	low			59
63.Bottom water temperature	warm	cold			7
67.Total suspended solids differential	inlet lower than outlet	inlet higher than outlet			0
68.Nutrient differential	inlet lower than outlet	inlet higher than outlet			0

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[a] The actual number of supporting research studies cited in Adamus 1983; Vol. I, chap. III of FHWA Report

> systems and were then applied uniformly across all wetland types. The panel's collective expertise concerning a variety of wetland types led us to conclude that the assumptions and hypotheses were invalid in many cases. For example, Predictor 15 (Landcover of Subwatershed) states that agricultural cropland or grazed pasture is best for food chain support, yet the predictor does not consider the problem of increased sedimentation (turbidity) and herbicide/pesticide runoff associated with such land use practices. Studies in Maryland have documented the deleterious consequences of agricultural practices in watersheds (Correll and Dixon 1980; Orth and Moore 1983).

The section on the ranking of wetland types (Adamus 1983: Vol. I, Chap. 3) presents the rationale for the comparative ranking of the wetland attributes used in the 75 predictors. It is clearly stated in this chapter, and elsewhere, that the 75 wetland attributes cannot vary independently of other attributes, except for the purpose of evaluation. A critical assumption of all rankings is that all other factors (predictors) are held equal (Adamus 1983: Vol. I, p. 48, emphasis by Adamus). The rationale for ranking is, therefore, often unclear (much less tested) or not evident in peer-reviewed research results. This lack of data is not a reflection on the author. Although the assumption on holding all other factors equal is clearly stated in the FHWA report, the rationale for ranking is often not stated as though all of the other factors are held constant. Unproven or questionable assumptions about ecosystem functions are introduced to support rankings. These "hidden assumptions" are often related to the idea that higher primary production rates are desirable. It is probably true that more consumption occurs with more primary production; however, it is not sufficient to state that substrate type (mud, sand, or organic; p. 70), osmotic stress (p. 71), or pH (p. 72), for example, influence food uptake equally when all other factors (predictors) are held equal. For these three factors, as well as others, the highest rating is reserved for wetlands with the highest primary production, which is supported, presumably, by an assumed direct relationship between primary production rates and predictor and between predictor and the ranking. Flowing water may stimulate primary production, and higher rates of primary production may allow more consumption, but it does not follow that increased water flow stimulates consumption by the important consumers. Viewed in isolation from all other factors, the highest consumption rates (downstream within the ecosystem) may be within a rubble, rather than a mud, environment because the organic standing crop may be lower in the latter due to greater predation. This is one example of assumptions that are 'hidden' or unsupported.

A listing of the panel's recommendations concerning the predictors utilized in the food chain key follows:

Predictors Acceptable Without Modification

1. Contiguity. In addition to the rationale that transport of food is more probable and effective in "open" basins (with both an outlet and an inlet), it is also true that fish consumers have

more opportunity to move or migrate into or through the system to utilize food resources produced in situ and transported to the basin.

33 and 34. Water depth (maximum/minimum). In addition to the rationale given for the presence of aquatic beds (and, thus, food production) in shallow systems, it also may be applicable that shallow systems with a productivity similar to deep systems have higher plankton densities for fish to consume.

52. Plants: Productivity. It is difficult to disagree with the statement that systems with high primary productivity have the potential for greater food chain support. However, no studies have been conducted to specifically test this assumption. Literature reviews that indicate this general relationship have a large amount of uncertainty associated with them.

58. Alkalinity. The panel agreed with this ranking for freshwater ecosystems.

Predictors That Require Modification To Be Acceptable

22. Vegetation Form. With one exception, ranking is impossible among vegetation forms because the value of a vegetation form is very site specific. The exception is a low ranking for moss/lichen vegetation. However, see Schell (1983) for the incorporation of fossil peat carbon into freshwater Arctic Alaskan food webs.

24. Salinity and Conductivity. The panel recommends that ranking not be done for salinity and conductivity, except for hypersaline conditions, which can be ranked low. Although decomposition rates may, in some way, be correlated with food chain support, the studies cited do not permit resolution of value among salinity regimes. Decomposition rates are probably more dependent on the plant species involved, ambient temperature, and hydroperiod of the site than on salinity or conductivity.

25. pH. The only ranking on the basis of pH that is justifiable is a low ranking for acid bogs, in part due to their low pH. This, however, duplicates the rationale in Predictor 22, above (vegetation form).

27. Flooding Duration and Extent. This predictor is related less to the effect of flooding on productivity than to either the: (1) opportunity for fish to expand their food resources; or (2) export of organic matter to open water.

28. Artificial Water Level Fluctuations. Artificial manipulations of the water level are generally perceived as undesirable, and the more severe they are, the less desirable they are. Few artificial water level regimes are compatible with the adaptations of native species to the hydroperiod. The alternate hypothesis stated in the FHWA report should be omitted. The original papers by Lantz et al. (1967) and Quennerstadt (1958) should be consulted rather than citing a paper that interprets the results of these papers.

31. Scouring. This predictor should be modified to give a higher ranking to (1) "moderate or unknown" than to (2) "severe and known."

36. Oxygenation of Sediments. First, use of the predictor should be limited to nontidal systems (i.e., those without thermohaline stratification). Second, the predictor should apply to the water column rather than the sediments, because most sediments are notoriously poorly oxygenated. Finally, for the water column, frequency and duration of deoxygenation are factors that should be ranked, and only severe, anthropogenically induced conditions should be considered. This is because "productive" monomictic and dimictic lakes typically develop hypolimnetic anoxia.

53 and 54. Invertebrate Density. Freshwater and Tidal Flat. Invertebrate densities (benthic) are part of the food chain; therefore, it is obvious that they contribute to food chain support. However, none of the panel members are aware of the principal source that is cited to justify the ranking (i.e., Diaz 1982 as cited in Adamus 1983).

57. Suspended Solids. This predictor should not be applied to tidal systems. However, there is no justification for ranking low and moderate concentrations of suspended solids. Unnaturally high turbidity in freshwater systems may be undesirable for certain species of fish. In any case, the relationship of suspended solids to food chain support is unknown.

Predictors Unacceptable to the Panel

2. Constriction. The panel questions the validity of constriction as a predictor of food chain support. The hypothesized rankings are unacceptable for a variety of wetland situations personally known to panel members. Two of the supporting references are believed to be inappropriately interpreted (Heinle et al. 1973; Chabreck 1981).

3. Basin Shape. Consensus of the panel is that there are no data to support the hypothesized ranking, and, in fact, arguments can be made for reversing the ranking depending on whether in-basin or downstream transport is being considered.

4. Fetch and Exposure. The rationale for this predictor does not appear to follow or support the hypothesized ranking (perhaps there is an error in the wording and the rationale is backwards). There is a possible conflict between in-basin and downstream food chain support. For example, depositional areas that are sheltered may have greater primary productivity. The panel's collective experience indicates that the generalization implicit in this predictor can not be supported.

13. Gradient of Basin. This predictor relies on varying factors that cannot, in reality, be equal or unchanging as the assumption requires. Supporting references are limited to forested wetlands, and it is impossible to generalize this information to other

wetland types. The supporting references of Brown et al. (1979) and Day et al. (1980) are considered inappropriate. The alternative hypothesis is believed to be misleading; i.e., in general, plants growing in a particular location are adapted to the stresses existing there.

15. Land Cover of Subwatershed. The panel believes that the assumed link between the land cover of the subwatershed and food chain support is obscure at best and inappropriate as a predictor. The reason that Predictor 16 was not included in the key for the food chain support function is unclear because the land cover of the subwatershed was included. Rankings are believed to be erroneous for a variety of situations (e.g., the recent Chesapeake Bay Studies conducted by the U.S. Environmental Agency; see Kemp et al. 1983; Orth and Moore 1983). The use of Sutcliffe (1972) is considered inappropriate, and the extensive use of chemicals in rural areas (i.e., pesticides) make the rationale for "D" doubtful.

23. Substrate Type. This predictor was believed by the panel to be unusable because substrate type covaries with so many other variables. Also, the hypothesized rankings cannot be generalized to a variety of wetland situations and still be considered valid.

26. Hydroperiod. The consensus of the panel is that the hypothesized rankings cannot be justified because there is no good evidence that any particular hydroperiod is better for food chain support in general. Hypothesized rankings may have to be modified to fit each consumer species (i.e., is the interest in ducks or finfish?).

29. Natural Water Level Fluctuations. There is no evidence to suggest that the tendency for a basin to be flashy or not flashy is related to the food chain support function.

30. Tidal Range. This predictor is relevant to a limited set of wetland conditions. Documentation for the predictor is limited to a few wetland types (e.g., salt marshes) and species (Spartina spp.). The Steever et al. (1976) reference is misinterpreted (i.e., there was no difference on a marsh average basis). The supporting evidence that is cited deals with the relationship between tidal range and net primary productivity and in no way links the predictor to the food chain support function.

32. Flow Velocity. The conditions under which measurements are made (i.e., time, place, and frequency) are of critical importance to this predictor. The great amount of variation possible makes this predictor very complex and difficult to justify. Wetland specificity is a necessity. The support references (Heinle and Flemer 1976, Odum 1980) are not appropriate. No good evidence exists that connects flow velocity to primary productivity and subsequently to the food chain support function.

41 and 42. Basin and Wetland Vegetation Density, respectively. The panel agreed that there is a qualitative relationship between

vegetation density and primary productivity and food chain support: however, there is no justification for the percent coverage levels utilized in the key to determine the level of food chain support. Because the size of the basin is critical to the level of support assigned to a particular wetland, the subjectivity inherent in determining what constitutes the basin is a potential problem.

43. Sheet vs. Channel Flow. This predictor was not considered to be of value because most storm-related flooding is sheet flow.

44. Wetland-Water Edge. Edge effect cannot be related to primary productivity or any subsequent food chain support. The support reference (Gucinski 1978) is believed inappropriate in this context.

45. Gradient of Edge. The consensus of the panel was that this predictor is totally unrelated to the food chain support function.

49. Plants: Form Richness. There is a general agreement among the panel members that diversity may have value as a food chain support function predictor. However, several points are unclear or unacceptable. For example, are phytoplankton included? How can the categories (classes, subclasses, and species) be used simultaneously? Which category is appropriate under what circumstances, and how are the categories defined? The references are not believed to support the hypothesized rankings or the cutoff value of "3" used in the key.

59. Eutrophic Conditions. The hypothesized rankings are erroneous. Highly eutrophic conditions may lead to situations that are unfavorable for secondary production. This predictor also is affected by the covariance of factors in different situations.

63. Bottom Water Temperature. The panel did not believe that a relationship between bottom water temperature and decomposition or primary productivity could be justified or supported with the present data base.

67 and 68. Total Suspended Solids (TSS) and Nutrient Differential, respectively. It is extremely difficult to accurately measure these and other variables linked to the hydrology of the wetland (see Hydrology section). Therefore, any "quick and dirty" technique must be suspect. With respect to nutrient differential, it is not necessarily true that phytoplankton will make up a significant portion of TSS. The lack of literature supporting the hypothesized rankings makes these predictors of little value.

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HABITAT PANEL

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INTRODUCTION

The Habitat Panel recognizes the need for a rapid assessment method that provides a state-of-the-art analysis of habitat vital to fish and wildlife. The FHWA method is the most complete and thorough procedure of its kind created to date and provides the following positive benefits:

1. It contains a listing, through questions, keys, and predictors, of virtually all known functions and other possible factors that influence the status and efficiency of wetlands;
2. The proposed system reflects, and attempts to utilize, interrelatedness of wetland functions and dependence of wildlife on various wetland functions;
3. There is a strong emphasis on fish and wildlife as a major product of the wetland system and;
4. The procedure ranges from a simple in-house assessment to several levels of increasing detail and analytical potential resulting from field work.

However, the panel sees weaknesses in the procedure as now stuctured that may prevent the method from achieving its goals. Based on the experience of the panel members with various wetland types and the ecological foundations for the predictors, we suggest that the answers derived will be inconsistent depending on the experience level of the observers. In addition, the results will not always place a wetland in the proper category because of the dramatic seasonal and year-to-year dynamics in vegetation and vertebrate populations.

In spite of the development and widespread use of the species-oriented Habitat Evaluation Procedure (HEP) of the U.S. Fish and Wildlife Service, there is need for a more rapid, community-oriented system that is more clearly tailored to wetlands. HEP can be used in conjunction with the FHWA system where detailed species-level data are desirable.

GENERAL OBSERVATIONS AND RECOMMENDATIONS

At present, the FHWA system is oriented toward conspicuous and important groups of birds, such as waterfowl and shorebirds. The panel believes that the system should reflect the entire vertebrate community by use of regional species lists that avoid bias toward groups, the absence of which might negatively influence the wetland valuation. The added parameters of vertical layers of vegetation are necessary both for the wetland and the adjacent wetland-influenced plant community in order to more accurately correlate vegetation to potential vertebrates. Vegetation zonation, cover-water interspersion, and other aspects of horizontal structure are well represented in the predictors but need better definition and clarification.

Although the logic of using individual predictors is generally good, the supporting database often relies on a few papers that pertain to only a few geographic regions or wetland types.

A vitally important concern is the weakness of the measurement of hydroperiod and related plant responses. Because arid region wetlands may range from 5 to 95% open water within a few years and wildlife populations may reflect 20-fold differences in populations between optimal and suboptimal habitat, it is imperative that some measure of the relationship between hydroperiod and plant responses be provided so that temporary lakelike conditions do not result in a reduced wetland value. The assessment must reflect mean water and habitat conditions over a series of 10 years in some areas to be accurate. The use of aerial photos taken over a period of years is recommended in this determination.

Shallow temporary or semipermanent wetlands in the glaciated prairie region may be totally dry for several years out of every 10. During these periods, the wetlands may be farmed, and their identification may be very difficult. Therefore, they may be overlooked during the dry years and not be evaluated as wetlands. There is no mechanism in the present FHWA system to deal with these cases.

A difficult and significant issue not treated within the present FHWA system or parameters is the importance of a single wetland as a component of a "wetland complex." Evaluation systems tend to place a high value on a relict or unique wetland but rarely recognize the fact that mobile wildlife (birds, mammals, amphibians, and reptiles) may use different wetlands to provide different resources at different times in their life cycle. Contiguity between wetlands is a measure of this function for fish and some amphibians, where adults live in one wetland type but spawn in another.

Individuals working in areas with unique wetland types expressed concern prior to the workshop that the FHWA system must be able to evaluate these types. While it is conceptually possible for one procedure to assess wetlands as diverse as permafrost-formed tundra ponds, Mississippi River bottomland hardwoods, and alkaline Great Basin wetlands, breadth tends to produce a superficial evaluation and reduce the potential for system sensitivity. Regionalization seems essential to enhance predictor effectiveness when such diverse wetland types are being considered. Regionalization may also provide a measure of the potential plant and vertebrate species richness for a given area, as well as provide indicators for hydroperiod and water quality. For example, work on the plant communities and water quality of glaciated prairie wetlands by Stewart and Kantrud (1972) strongly suggests that an evaluation of plant communities can provide better insight into mean hydroperiod and expected water quality than can limited on-site measurements of water depth and conductivity that only reflect current conditions.

The establishment of the boundaries of a wetland is an issue that continues to create problems in wetland classification and influences how a wetland is appraised. In arid regions, the hydrologic influence of the wetland on surrounding vegetation can be large. Therefore, the surrounding area should be considered wetland-influenced, even though the vertebrate species in the area may be more typically considered terrestrial. This relationship has important legal implications for riparian habitats.

A related issue concerns "terrestrial" wildlife (species not specially adapted to wetlands that spend most of their time and obtain most of their resources in terrestrial systems) that often use wetlands as cover or food resources during the winter or during dry periods. These species are technically part of the "wetland community" because they utilize wetland resources; however, there are concerns as to whether or not deer and pheasants (for example) should be classified as wetland wildlife.

Like the other predictors, those for fish (31 predictors) and wildlife habitat (33 predictors) lack a hierarchical arrangement according to breadth, importance, or any other ranking system. The panel believes that, once properly evaluated, selected predictors can be arranged in a dichotymous key, starting with predictors with the broadest implication and ranging to the detailed parameters essential to differentiate wetlands at a more refined level. This key would facilitate decisionmaking while maintaining a clearer perspective of the progression toward the goal of wetland habitat evaluation.

The guilding system is another approach to assessing vertebrate communities that can be utilized as part of the FHWA key or that can stand alone as a technique that uses only a few of the predictors. Although the guilding system generally is accepted from an ecological perspective as a technique to analyze a community in terms of niche space and habitat resources, its sensitivity as a wetland assessment tool is yet to be evaluated. Simply put, the structure of the vegetation used for two significant functions of the vertebrate community is combined in a matrix to form guild "blocks" (Fig. 1). Species within a particular block correspond to "wildlife guilds" because they reflect diverse species or groups of species that utilize the same habitat strata in the same manner (although the precise foods or breeding sites utilized might differ). The potential number of guilds in a habitat can be compared to the actual number of guilds present. In this way, different wetlands can be compared in terms of their ability to support wildlife or changes within a wetland can be evaluated (see Short and Burnham 1982 for further details of the guilding system).

The FHWA system can be used to compare two different wetlands or the same wetland at different times. However, the panel believes that it should not be used mainly as an impact assessment tool because this would require specific information about perturbations not currently considered in the FHWA system.

Other format and procedural details that would facilitate the use of the FHWA system involve a greater use of graphics within the report; the computerization of both the analysis and interpretive phases; and a clearer separation between desk procedure, field procedures, and the third order, detailed study. Appendices to the report that provide guidelines or procedures for a detailed assessment would be helpful for areas of similar habitat where a more detailed analysis is desirable.

Layers Where Feeding Occurs

	HT	LT	Sh	E	Su	B
High Tree (HT)						
Low Tree (LT)						
Shrub (Sh)						
Emergent (E)		A	A	A B		
Surface (Su)						
Bottom (B)						C

Layers Where Reproduction Occurs

Figure 1. Guild blocks based on the use of layers of wetland habitat for feeding and reproduction. For example, species A feeds in emergents and nests in low trees, shrubs, or emergents. Species B feeds in emergents with Species A but nests only in emergents. Species C breeds and feeds only at the bottom of the water column.

Several members of the panel strongly favor a 1 to 5 ranking instead of the present high, medium, and low. Someone with skills in questionnaire design should be involved in order to avoid response biases. Greater evaluation precision might be achieved if a 1 to 5 ranking system resulted in a more considered analysis. Moreover, greater sensitivity of predictors in determining the degree to which a wetland fulfills a function allows for more precise evaluation conclusions.

The panel suggested five new predictors for the FHWA system in order to accomodate the recommended change from a species to a community-oriented analysis:

1. Carp. The presence of carp is negative because of carp-related damage to submergent vegetation and increased turbidity.

2. Layers of Vegetation in Wetland. This data is essential for use of the guilding system.

3. Layers of Vegetation at Wetland Edge (subwatershed). These data contribute to the understanding of adjacent wetland-influenced communities and is used in the guilding process.

4. Cover for fish. This predictor involves an analysis of vegetation of various types for the protection of fish eggs, nests, or young.

5. Contribution to wetland complex. This predictor is a measure of the spatial and functional relationships of a wetland with other wetlands within the home range of mobile wildlife.

RESEARCH NEEDS

One of the most significant contributions of the FHWA system and its predictors is to focus attention on the present level of knowledge about wetland functions and the desired database. Many predictors have a fairly firm basis in observational data and a few have been tested experimentally, but most of the predictors are based on a few, highly regionalized observations that could be very atypical or site specific. Especially lacking are systematic observational data resulting from types of studies not currently encouraged or financed: (1) descriptions of plant communities as related to water depth, water chemistry, invertebrate fauna, and vertebrate fauna; and (2) analyses of the influences of community structure and physical characterisitics of the environment on vertebrate populations.

Long term studies especially are needed to relate the dynamics of the vertebrate community to the dynamics of hydroperiod, water chemistry, and the plant community. Most research funding is for one to three seasons, which may involve only part of a species' life cycle. These short research studies could involve all dry years or all wet years, resulting in a very biased evaluation of habitat conditions and how the habitat is utilized by fish or wildlife.

Special attention needs to be devoted to fish, amphibians, and reptiles in wetlands. Although, more studies have been made of birds, many of these studies are biased by short term observations. Fish and aquatic amphibians (especially certain life stages) have not been studied intensively except in estuaries, partly because of sampling and observation difficulties, but also because of our failure to recognize the importance of these animal groups in food chains and of the importance of wetlands in meeting the life requirements of selected species.

Another area of needed research is a field test of the FHWA evaluation system. This testing can take place in two ways, the more usual way being an assessment of operational aspects of the system, such as user satisfaction and goal achievement. Far more important is the opportunity to test the method against a known wetland where the values and functions already have been assessed. This type of test documents the suitability and sensitivity of the FHWA predictors. The interaction of the individual predictors in terms of the total assessment process could be evaluated through statistical analysis. One result of statistical analyses is to reduce the number of relevant predictors, but at the same time, avoid overlap and possible cumulative effects.

ANALYSIS OF KEYS AND PREDICTORS

The panel analyzed all 75 FHWA system predictors with an emphasis on those predictors that were, or should be, used to evaluate fish and wildlife habitat. In conjunction with Paul Adamus, the author of the FHWA report (Adamus 1983), justifications for the predictors were clarified and terminology was corrected or adjusted as needed. Several predictors were dropped because they were judged to be too difficult to use in the present system. Several predictors in the wildlife key were also added to the fish key (Table 1). In addition, a cross check of the listing in keys (and tables) discovered some confusing typographical and other errors (Table 1).

The panel is concerned about the large number of predictors dealing with certain topics, like water (24, 26, 27, 28, 29, 32, 33, 34, 36, 38, 57, and 58) and basin morphology (1, 3, 4, 5, 6, 10, 44, and 45), that have overlapping characteristics. The cumulative effects of this overlap are uncertain but it seems logical to include only predictors with a more functional value.

The keys, which are mostly data tables for certain aspects of fish or wildlife habitat, contain valuable background information and seem to be thorough and well documented. Some of the data on foods are out of date in view of current methodology, but these needed updates can be accomplished by someone with the suitable expertise. Whether the keys should have a role in terms of the predictors depends on whether the ultimate system that evolves maintains its focus on waterfowl and shorebirds or considers the entire community in a structured way. Data, such as that required in the predictors, would be valuable for dichotomous decision keys, but probably are not available in the same degree for groups other than waterfowl.

The panel recommends the following changes in terminology or use and evaluative comments on selected predictors currently in the FHWA system (also, see Table 1):

1. Contiguity. The importance of this predictor to fish migration and spawning and waterbird food resources (especially waterfowl) should be added to the fish habitat (FH) and wildlife habitat (WH) keys.

4. Fetch and Exposure. Relate this predictor to increased turbidity that reduces the value of an area as a source of fish and waterfowl foods.

8. Basin Area and Subwatershed Ratio. Add this predictor to (FH) and (WH) because of indirect effects on turnover, eutrophication, and diversity.

Table 1. Recommended modification of predictors for fish and wildlife keys in FHWA methodology.

	Fish habitat key		Wildlife habitat key	
Predictor	Occurrance in FHWA report[a]	Recommended action[b]	Occurrance in FHWA report[a]	Recommended action[b]
1	2,K	N	1,2,K	N
2		N		N
3	1,2,K	N	1,2,K	N
4		A	1,2,K	N
5	1	A	1,2,K	N
6	1	A	1,2,K	N
7		N		N
8		A		A
9		N	2,K	D
10	1,2,K	N	1,2,K	N
11		N		N
12		N		N
13		N	M	D
14		N		N
15	1,2,K	N	1,2,K	N
16		N		N
17		N		N
18		N		N
19		N		N
20	1	A		A
21	1,2,K	N	1,2,K	N
22	2,K	N	1,2,K	N

Table 1. Continued.

	Fish habitat key		Wildlife habitat key	
Predictor	Occurrance in FHWA report[a]	Recommended action[b]	Occurrance in FHWA report[a]	Recommended action[b]
23	1,2,K	N	1,2,K	N
24	2,K	N	1,2,K	N
25	1,2,K	N	M	A
26	M	A	1,2,K	N
27	1,K	N	1,K	N
28	1,2,K	N	1,2,K	N
29	1,2,K	N	1,2,K	N
30		A	M	A
31		N	1,2,K	N
32	1,2,K	N	1,2,K	N
33	1,2,K	N	1,K	N
34	1,2,K	N	1,2,K	N
35	1	N		N
36	1,2,K	N	1,K	N
37		N	2,K	N
38	1,2	N	1	N
39	1,K	D	2,K	D
40	1,2,K	N		N
41	1,2,K	N	1,2,K	N
42	1	A	1,2,K	N
43		N		N
44		A	1,2,K	N

Table 1. Continued.

Predictor	Fish habitat key Occurrance in FHWA report[a]	 Recommended action[b]	Wildlife habitat key Occurrance in FHWA report[a]	 Recommended action[b]
45		A	1,K	N
46	1,2,K	N	1,2,K	N
47	2	N		N
48		N	1,2,K	N
49		A	1,2,K	N
50		N	1,2,K	N
51		N		N
52		N		N
53	1,2,K	N	1,2,K	N
54		A	K	N
55		N		N
56		N		N
57	1,2,K	N	1	A
58	1,2,K	N	1,2,K	N
59	1,2,K	N		N
60	1,2,K	N	2	N
61		N		N
62		N	M	A
63	1,2,K	N		N
64	1,2,K	N		M
65		N		N

Table 1. Concluded.

Predictor	Fish habitat key Occurrance in FHWA report[a]	 Recommended action[b]	Wildlife habitat key Occurrance in FHWA report[a]	 Recommended action[b]
66		N		N
67		N		N
68		N		N
69		N		N
70	1,2	N	2	N
71		N		N
72		N		N
73		N		N
74		N		N
75		N		N

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[a] Occurrence in FHWA report:
- 1 - Discussed in FHWA report (Vol. I).
- 2 - Coded in FHWA report (Vol. II).
- K - Occurs in FHWA report key.
- M - Report indicates that predictor is in the key, but it is actually missing.

[b] Recommended action:
- A - Add to key.
- D - Delete from key.
- N - No action. Leave predictor as is.

21. Wetland System. Consider moving this predictor to an earlier position, perhaps Predictor 1.

23. Substrate Type. This predictor should be included in FH with regard to warmwater fish, even though the data base is poor.

24. Salinity and Conductivity. Add the rationale for the inclusion of this predictor in FH. Move the salinity-conductivity conversion to a more useful position in the text. Consider using conductivity only.

25. pH. Add the rationale for including this predictor in WH.

26. Hydroperiod. Develop plant indicators for this predictor and add the rationale for FH (flooding influences the amount of habitat available to fish and meets seasonal needs).

27. Flooding Duration and Extent. Reconsider the terminology used in this predictor.

28. Artificial Water Level Fluctuations. Avoid the word "drastically."

30. Tidal Range. Add this predictor to FH because of migration and invertebrate populations in estuaries.

32. Flow Velocity (Mean). Typographic error, Vol. II., p. 76, Table 2: change the heading for velocity from question 22 to read question 32.

35. Width. Delete the narrative on fish.

38. Flow Blockage. There is a problem with the terminology; drop the discussion of this predictor for FH and WH.

41. Basin's Vegetation Density. Change density to cover (cover-water ratio).

44. Wetland-Water Edge. Change wetland edge to cover.

46. Shoreline Vegetation Density. Change terminology (e.g., shoreline character), and add vegetation layers.

53 and 54. Freshwater Invertebrate Density and Tidal Flat Invertebrate Density, respectively. The panel questions the feasibility of the listed methods. These predictors should be emphasized as long term, detailed study as opposed to one or few observations. Consider the use of "taxa richness" as an alternative to these predictors.

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SOCIO-ECONOMIC PANEL

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INTRODUCTION

The objectives of this panel were three-fold: (1) to suggest modifications for improvement in the Adamus (1983) two volume FHWA report; (2) to critically evaluate two functional values, Active Recreation (Section 2.9) and Passive Recreation and Heritage Values (Section 2.10), as they relate to the ability of the method to assess the socio-economic utilization potential of a wetland; and (3) to determine research needs.

GENERAL OBSERVATIONS AND RECOMMENDATIONS

First of all, the socio-economic panel suggests that "Socio-Economic Utilization Potential" be used to define their mission as related to the wetland value assessment. This heading includes, but is not limited to, the last two functional values in the FHWA report: 2.9 (Active Recreation) and 2.10 (Passive Recreation and Heritage), as well as economic considerations. This new designation provides, in our opinion, a more meaningful framework for incorporating both nonconsumptive and consumptive wetland values. It also recognizes the various hierarchical levels of utilization of wetland value information, including individual, societal, and global. Table 1 illustrates four categories of these socio-economic values: A. Experiential - recreational, visual, and educational activities (nonconsumptive); B. Consumptive; C. Nonconsumptive/societal; and D. Global functions expanded with their many values or utilities. These categories are defined as follows:

> Experiential uses refers to the use of a wetland that involves contact between people and the wetland and may be considered contact-dependent. These uses are generally nonconsumptive and dependent on the physical, biological, and hydrological characteristics of the wetlands, the mode of experiencing the wetland, the perception of the value by the user, and the information gained by the user. Experiential values are often very difficult to describe in dollar values and, therefore, experimental data may be incompatible with economic analyses.
>
> Consumptive are actual or potential uses of wetlands that involve a consumable product that can be taken away from the wetland area. Consumptive values are generally suitable for input into an economic analysis.

Table 1. Socio-economic utilization potential categories.

A. Experiential Uses: recreational, visual, and educational activities (non-consumptive)

1. Swimming
2. Boat launch/anchor
3. Power boating
4. Air boating
5. Canoeing
6. Kayaking
7. Sailing
8. Ice skating
9. Snowmobiling
10. Cross-country skiing
11. Nature study; e.g., birdwatching
12. Education
13. Photography
14. Research
15. Sightseeing (replaces aesthetic)
    - bike trail
    - horse trail
    - scenic roadway
    - access structures
        - -- piers
        - -- boardwalks
16. Swamp buggying
17. All terrain vehicle use
18. Recreational food gathering
19. Wetland art
20. Literary works
21. Historic relevance

B. Consumptive Values

1. Commercial fishing
2. Fur harvest
3. Aquaculture
4. Timber harvest (timber presence, soil suitability)
5. Commercial food gathering
6. Peat harvest (peat presence, tons/ac)
7. Agriculture
    - -forage
    - -crops
8. Water supply
    - -agricultural
    - -domestic
    - -municipal
    - -industrial
9. Biomass harvest (e.g., cattails)
10. Hunting

Table 1. Concluded.

B. Consumptive Values

11. Fishing
    - fin
    - shell
    - sport

C. Nonconsumptive/Societal Values

1. Preserving future options
2. Open space
3. Local climate amelioration
4. Wilderness/semiwilderness
5. Landscape/heritage values
6. Ecological balance

**7. History of science research or educational use
**8. Only wetland, or one of a few wetlands, near a population center
**9. At least locally an unusual ecosystem
**10. Actual site of art or poetic subject
**11. Official recognition feature; e.g., a National landmark
**12. Vital element to a wetlands system; e.g., a nursery habitat
**13. Has a rare, endangered, restricted, endemic, or relict flora or fauna
**14. Has a wetland type that is relatively scarce in a given physiographic region
**15. Has a flora of unusually high visual quality
**16. Has outstanding or uncommon geomorphological features
17. Has several so-called stages of wetlands type "succession" in close juxtaposition
18. Has high use or production by water, marsh, and shore birds
**20. With known presence of archaeological evidence
**21. Potential acquisition consideration

** = red flag condition

D. GLOBAL

1. carbon sink
2. gene pool maintenance
3. climatological/atmospheric aspects

Nonconsumptive/societal values include uses or values that result from the natural intrinsic functions of wetlands that generally benefit society as a whole and are not enjoyed by a specific group of people or within a limited time frame.

Global functions are functions that relate to the maintenance of our life support systems.

Socio-economic utility or Utilization potential refers to the anthropogenic use of wetlands, including the global or life support values of wetland to mankind.

It should be noted that not all consumptive or societal values that can be evaluated are included in this report. For example, water supply and waste assimilation were considered by other panels. Some of these values may be looked at from an economic perspective.

It is necessary to develop predictors for the individual items listed under the four categories in Table 1. This can only be done after sufficient literature review and integration of proven relationships and mechanisms has occurred. Some subjects need further research before valid predictors can be developed. An example of some socio-economic utilization potentials and possible related predictors are in Table 2. Some of the predictors from the FHWA report are included, as well as new predictors proposed by the panel.

The Socio-Economic Panel agreed unanimously that it was inappropriate to include monetized predictors dealing with the socio-economic utility of wetlands in assessment methodologies. The Panel considered that its economics charge (i.e., socio-economic panel) invoked the generic definitions; namely, the allocation of scarce resources. Batie and Shabman (1982:256) define economics as: "...a study of human choices -- of how people allocate resources among competing alternative uses to maximize their own well-being." Thus, the key to choice-making on wetlands utilization is to "maximize" the "well-being" of people.

It is possible to attempt to measure the maximization of well-being in the marketplace or through a simulation of the marketplace where the evaluator is dollars. It is also possible to try to determine what contributes to well-being by approaches that integrate the large range of societal values attached to wetlands. The panel chose the latter method and developed a set of utility categories, along with an example set of integrative socio-economic predictors. The panel believes that only the "consumptive" group has any real chance of being monetized because it deals with natural goods and services to which dollar values might reasonably be assigned.

Table 2. Examples of Socio-economic Utilization Potential Predictors.[a]

1. Canoeing, kayaking. Flow velocity, water depth minimums, stream length, water quality, vegetation form and richness, width, accessibility, contiguity, and NWI classification.
2. Nature study, education, photography. Species richness, interspersion of wetland types, accessibility, demography, length of season, suspended sediments, and water quality.
3. Sightseeing. Visual and physical access, edge gradient, flood duration and extent, wetland width, waterfowl value, and water/vegetation interspersion.
4. Ecological balance. Contiguity, basin surface area, wetland surface area, basin area/water area ratio, location in watershed, and stream order.
5. Open space. Demographics, basin area, watershed/area ratio, land cover of subwatershed, wetland system, vegetation form, and artificial water level fluctuations.
6. Gene pool maintenance. Endangered species, floral and faunal species richness, ecosystem stability, scarceness of habitat.

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[a] Underlined predictors are examples of predictors added by the panel.

Yet, even here, the techniques are weak, particularly when "shadow values" must be created. Batie and Shabman (1982:274) conclude: "...it is doubtful that research can move forward rapidly enough to provide the [dollar] value analyses needed to expedite individual land parcels for permit-based programs." The panel agrees with this opinion but, at the same time, believes that monetary equivalent evaluation may be appropriate for other purposes (e.g., appraisals for land acquisition for natural areas).

The panel understands that valid dollar valuation techniques for wetlands (in the context of assessment methodology) are not available. We also believe that no monetary approach could ever effectively integrate the multitude of societal "well-being" factors that are of concern in wetland regulation. Certainly, the Federal mandates to protect wetlands are not based on maximizing dollar outputs from these resources. Instead, they are based on "public interest" (or societal well-being) purposes that are traditionally determined in other ways, usually involving "normative" (judgmental), rather than technical, procedures.

The search for monetary valuation systems in the context of regulatory programs is most often connected with "benefit/cost" analyses that use dollars as the measure. There is a substantial literature that both accepts the legitimacy of benefit/cost analysis and warns against it as a substitute for more socially appropriate means of making environmental decisions. For example, Kelman (1982:138) warns: "There are a number of reasons to oppose efforts to put dollar values on nonmarketed benefits and costs beyond the technical difficulties of doing so." He concludes: "Given the relative frequency of occasions in the areas of environmental, safety, and health regulation when it is not desirable to use a 'benefits outweigh cost' test as a decision rule, and given the reasons to oppose the monetizing of nonmarketed benefits or of costs - a prerequisite for cost-benefit analysis - it is not justifiable to devote major resources to generate data to be used in cost-benefit calculations."

The panel suggests the following, rather specific recommendations, for the improvement of the FHWA system:

1. An introductory section on wetlands is needed that includes their present status in the U.S.; e.g., 40% of our wetlands have already been lost, and wetlands now represent only 3% of the Nation's landscape. Annually, 458,000 acres of wetlands are lost (Frayer et al. 1983), and a vast literature suggests that all of the remaining wetlands are valuable. As one panel member (Daniel Willard) indicated, "It is essential that the burden of proof remain on the person or agency who wishes to change the wetland. The existing wetland is the best use unless proved otherwise. When no data exists, no change may occur. When in doubt, don't. This attitude requires the agencies to become developers of the database."

   It is essential that persons involved in wetland assessment understand the state of our knowledge of the functional role of wetlands. This literature is reviewed with the literature documentation later in the FHWA report, but a brief introductory overview is essential. This wetland philosophy/values section can be done in one or two pages. It should also be mentioned that Congressional and public support for wetland protection is at an all time high. However, in order to remain objective, wetland nuisance problems, such as human health, odors, and mosquitoes, also should be addressed.

2. A flow chart, illustrating how the system works and accompanied by an explanation of the system, should be included early in the report. The panel modified Figure 1 in Volume II, as indicated in Figure 1 in this report. It should be noted that two insertions have been made; red flag and active use. Red flag areas (Larson 1976) are defined as unusually significant wetlands. The criteria used to designate red flag areas are listed in Table 1 under Nonconsumptive/Societal Values. The Water Quality Panel also suggested modification of this flow chart; the best of the two modified flow charts should be combined. A separate section in the flow diagram for human significance (Functional Significance)

is a notable addition and helps to highlight those socio-cultural values that are emphasized in this report but often overlooked elsewhere.

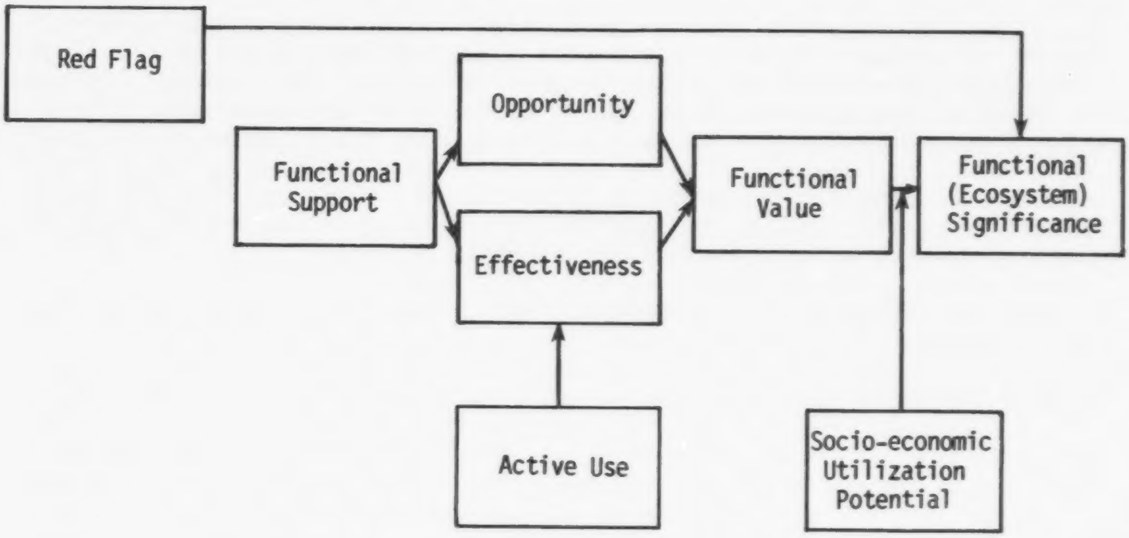
Red Flag
Opportunity
Functional Support
Effectiveness
Functional Value
Functional (Ecosystem) Significance
Active Use
Socio-economic Utilization Potential

Figure 1. Modified Flow Chart.

3. The current format of the FHWA report needs upgrading in terms of fully explained graphics with meaningful legends and an overall reorganization of material for greater usefulness. All of the abbreviations used need to be clear and spelled out each time they are used in a separate figure or table.

4. There needs to be one standard assessment procedure with regional modifications that respond to both natural and political divisions.

5. Consideration should be given to modifying the high, medium, and low rating system into five categories, possibly A, B, C, D, and E. Do any wetlands really rank LOW?

6. There should be a "No Data" column in in addition to "yes" and "no" response categories. The proportion of "no data" responses should then be used to assign a validity modifier to that particular evaluation result.

7. Regional training prior to use of this system is essential. Multilevels of training (e.g., administrators or field biologists) should be considered.

8. With the publication of the Adamus (1983) document, it is essential that a FHWA supplement be prepared within the next 6 months to a year that incorporates the suggestions resulting from this National Wetland Values Assessment Methodology Workshop.

In conclusion, the panel strongly advises any Federal agency interested in exploring the potential of the FHWA assessment methodology to develop a detailed set of utilization, or potential utilization, categories to accompany the ecological "function" categories that are the emphasis of the FHWA method. We also recommend that these categories and their predictors be based on their utility to society on a ranking system, not on a dollar scale. Furthermore, well established societal values should be given priority status through the suggested red flag system, as predetermined policy for the allocation of resources among competing uses.

RESEARCH NEEDS

There is available literature in the socio-economic area that should be carefully screened and utilized. There is also a need for further research into validating the predictors for experiential, consumptive, nonconsumptive/societal, and global areas. Our knowlege of the biospheric significance of wetlands as an aid to our life support system on a global scale is incomplete. For example, methane (CH_4) is believed to function as a homeostatic regulator in relation to the ozone layer that currently protects aerobic organisms, including man, from the harmful effects of ultraviolet radiation (Sze 1977; Odum 1979). We do not know if the uncontrolled incremental destruction of wetlands can lead to unfortunate consequences because these liquid assets may be significant in this interacting role on a global basis. A large knowledge gap exists in the area of how to relate such far reaching values (cumulative effects) to individual wetlands.

Other research needs and questions that need to be considered in the area of socio-economics and were identified by this panel are listed below:

1. How generalizable are the predictors of wetlands values?

2. Are socio-economic utilities/predictors usable all the way through the system, including mitigation enhancement and wetland creation?

3. What are the demographic relationships of the socio-economic utility of wetlands?

4. Further psychological/social studies on the experiential values of wetlands, in cooperation with physical scientists and landscape designers, are needed.

5. Controlled experimental field testing of any assessment methodology developed is essential to determine the validity, accuracy, and precision of the system.

ANALYSIS OF KEYS AND PREDICTORS

The panel reviewed the predictors relevant to the socio-economic subject area and believes that this section is inadequate and requires modification in light of the restructuring and expansion of the concept of socio-economic utilization potential outlined earlier in this report.

The treatment of socio-economic utilization potential by Adamus (1983) was limited largely to predictors of active recreational value, and the scientific validity of predictors for passive recreation and heritage values was not accepted (p. 47). This indicates the need for an in-depth review of the literature on this subject from several disciplines as a first step in improving the methodology. Although all of the recognized functional values of wetlands are inherently related to human perceptions of values, and thus to socio-economics, the review should be limited mainly to literature dealing directly with socio-economic utilization potential. This step is intended only as a reference point for a more thorough review.

Literature on socio-economic utilization potential has been best reviewed by Sather and Smith (in prep.), Fritzell (1979), Gannon et al. (1979), Jaworski and Raphael (1979), Niering (1979), Reimold and Hardisky (1979), Smardon (1979), Williams and Dodd (1979), and Smardon (1983).

The active recreational use of wetlands should be reviewed, especially work by Dave Lime at the U.S. Forest Service North Central Forest Experiment Station in St. Paul, Minnesota. This research has coordinated recreational carrying capacity for the Boundary Waters Canoe Area. Demographic factors and modifiers are covered in Smardon (1983).

Consumptive utilization is covered by the panels on Wetland Heritage and Wetland Harvest in Greeson et al. (1979) and in Richardson (1981). Additional literature should be reviewed in the areas of timber harvest, aquaculture, rice culture, cranberry production, and peat harvest. Research on use of wetlands for hunting and fishing should be reviewed, although this literature is widely scattered.

References with specific information that supports predictors of the socio-economic utilization potential of wetlands are:

Experiential
Greeson et al. (1979) (heritage section)
Smardon (1979)
Smardon (1983)

Consumptive
Krutilla and Fisher (1975)
Greeson et al. (1979); (harvest panel)
Smardon (1979)

Nonconsumptive/societal
U.S. Fish and Wildlife Service (1962)
U.S. Forest Service (1977)
Greeson et al. (1979)
Smardon (1979)
Richardson (1981)
Smardon (1983)

Global
Odum (1979) bibliography

Philosophies concerning the economic valuation of wetlands vary widely. However, research in this area by economists and sociologists, as well as by ecologists, must be thoroughly reviewed to ensure the valid use of economics as a tool when necessary. One example of current research in this area is that of J. Yumeji on the costs and benefits of wetland developments on the California coast (School of Urban and Regional Planning, Univ. Southern California, Los Angeles, unpubl. rep.). Available literature that addresses the economics issue includes Isard (1968), Bouma (1976), Ehrenfeld (1976), Nijkamp (1976), Dohan (1977), Friedman (1977), Vaux and Williams (1977), Shabman and Batie (1978), Meyer (1979), Raphael and Jaworski (1979), Meyer (1980), Abdalla and Libby (1981), Shabman and Batie (1981), Sinden and Windsor (1981), Batie and Shabman (1982), Kelman (1982), and Wingo (1982, bibliography section).

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RESPONDING COMMENTS

Paul R. Adamus, author of the FHWA method (Adamus 1983)

My responses are first to issues raised by more than one panel, and then to specific points made by a single panel.

RESPONSE TO ISSUES RAISED BY MORE THAN ONE PANEL

Issues raised by more than one panel include the following:

1. The adequacy of the present scientific data to support wetland evaluation.
2. The need for rechecking predictor rankings for covariance effects and hidden assumptions.
3. The need for specifying the uncertainty associated with each rating.
4. The need for calibration of the FHWA system against wetlands of known value.
5. The need for a more regionalized treatment of functional values.
6. The need for better accounting of the dynamic nature of wetlands.
7. The need for rechecking the accuracy and appropriateness of the references.
8. The need for streamlining the method.
9. The need for incorporating some sort of red flag feature in the system.

Adequacy of Present Scientific Data

Some workshop participants indicated a belief that rapid assessment techniques cannot distinguish (even in the most extreme cases, perhaps less than 5% of all wetlands) wetlands that are obviously of high or low value for ground water exchange or food chain support. Some other participants noted that minimum levels of data adequacy need to be established.

Government policymakers involved with issues as diverse as the regulation of pharmaceuticals and acid precipitation must, unfortunately, act on incomplete knowledge. They are handed legislative mandates or institutional objectives that imply a need for prioritizing wetlands and addressing such vague topics as "productivity". Scientists, however incomplete their data, are better qualified than lay people in terms of providing decisionmakers with preliminary assessments of most wetland functions. This is so because scientists are familiar with the processes that bear indirectly on the function.

While it is sometimes necessary to base functional assessments on hypotheses that are based on hypotheses, that are based on still other hypotheses, the hypotheses at each level may be "reasonable", based on known relationships, and, in any case, can be made very explicit. The FHWA document has sought not to "obscure [subjective impressions]... by invoking a complex and seemingly sophisticated scientific assessment procedure" (Food Chain Panel report; p. 40). If the method seems complex, it is because of a desire to reveal, rather than obscure. Complexity has stemmed from the need to comprehensively identify subjectivity. As future revisions of the method are prepared, I will further strive to identify underlying assumptions and explain these without increasing overall complexity.

The procedure is intended primarily as a communication tool. It aims to make wetland decisionmaking more explicit, accountable, and systematic and to provide guidance in setting priorities for a more detailed analysis. Many decisionmakers are aware of data limitations and most will use the method as only one of many inputs in their decisionmaking. Thus, the Hydrology Panel's statement (p. 17) that the FHWA method encourages the formulation of "definitive statements about recharge and discharge from maps or site visits" contrasts with the introduction to Volume II (p. 1), which states that "the procedure should not be used where questions regarding wetland functions must be answered definitively."

It is imperative that more assessment-related wetland research be funded quickly. Until the results from this research are available, it is essential for wetland decisionmakers to consider standardized sets of characteristics and assumptions. What might otherwise happen is that decisions regarding wetland productivity, for example, will be made in many inconsistent ways, ranging from standing crop measurements to hunter bag checks to flushing capacity modeling to simple political influence.

Covariance Effects

During the workshop, most panels first considered the relevance of the predictors, on an individual basis, to the panel's topic, as addressed in Volume I, Chapter 3, of the Method. Later, the panels looked at the ways that the predictors interacted, as addressed by the interpretation keys in Vol. II. My experience in attending several different panel sessions was that most panels, because they spent most of their time considering the predictor rankings, had little or no time available to review the interpretation keys. This, perhaps, is partly the cause for the perception of some panel members that the FHWA method overlooks predictor interactions (covariance). The document acknowledges that the approach taken in Chapter 3, holding all other factors equal while the conditions of one factor are ranked, is simplistic. However, Chapter 3 is only a partial explanation for what was done in the interpretation keys. Although the interpretation keys will be rechecked for biases due to covariance in the future, they presently are structured in such a way that I believe that the effect of covariance on the final ratings of most wetlands would be insignificant.

Specifying Uncertainty Associated with Each Rating

The FHWA report currently specifies (in Chapter 3) the relative level of uncertainty associated with the underlying hypotheses. However, as several panelists noted, no measurement of the uncertainty in the final ratings derived from the interpretation keys is given. This is especially important because data availability may vary greatly among the wetlands being assessed.

In future revisions of the report, I will consider the use of techniques derived from rule-based logic systems (such as inference networks; see Duda et al. 1976, 1979; Ischuzuka et al. 1980) in order to quantify uncertainties in the final ratings.

Calibration Against Wetlands of Known Value

Calibrating results from the FHWA method against wetlands of known high or low value for specific functions in each region is an excellent suggestion. This calibration requires extensive communication with local researchers, and, in some regions, adequately researched areas may not be available to calibrate some functions. Calibration results may be tied to inference network measures, mentioned above, to yield a useful sensitivity analysis.

Regionalization

Many parts of the FHWA method have been regionalized. For example, regional differences in waterfowl habitat preference are reflected in the guidelines for the selection of appropriate indicator species (Vol. II, pp. 35-37). Regional differences in water balance (p. 34), primary productivity (pp. 23-33), oxygen stratification (p. 12), waterfowl foods (pp. 20-21), and waterfowl wintering habitat (i.e., conditions, pp. 79,83) are also recognized.

The idea of future regionalization of the FHWA method is a good one. Regionalization should be undertaken when it can be shown that the processes underlying a function do, in fact, vary in a particular region from the generalized model, rather than automatically assuming that they do.

Dynamic Nature of Wetlands

Wetlands are extremely dynamic and forecasting wetland changes is very difficult. Even so, predictions must be made. Wetlands that presently are of high value for sediment trapping, for example, may be of low value in 20 years due to an overly effective performance of the function (filling in) or to other unrelated causes. Consequently, the wetlands of highest value might sometimes be those that currently are less effective for some self-destructive function, but which are capable of performing the function on a sustained basis. In the case of mostly nondestructive functions, such as waterfowl use, the challenge is to infer the mean year-to-year natural variation from a single visit. In the case of self-destructive functions, such as sediment and nutrient trapping, predictions of the effect of the function must be considered at the same time as predictions of natural variation, thus compounding the problems in making the analysis.

The FHWA method recognizes the dynamic nature of wetlands. Wet season - dry season variation is addressed in Response Sheet A1 (Volume II, p. 51) and question 27 in Form A (Volume II, p. 10). Year-to-year variation is addressed in Volume II on pages 4 (paragraph 3), 10 (question 26), 19, and 38 (question 1). No guidelines are provided for actually forecasting wetland resistence, resilience, and, ultimately, change, although parts D through G of Form C (p. 47) and Chapter 5 in Volume I provide some foundation for predicting future conditions. The topics of predicting wetland resistance, resilience, and impact should be the focus of a special workshop or symposium, as well as considerable well-focused research. Until such time, I believe that the data are usually too scanty to allow more accurate forecasting of wetland change by rapid assessment methods.

Rechecking the Accuracy and Appropriateness of References

Some concern was expressed about the manner in which literature was listed in Chapter 3 (Ranking) of Volume I and the appropriateness of citing certain studies. In explanation, it is relevent to note the statement on page 49, Volume I: "The inclusion of a literature citation does not necessarily indicate the cited source supports the ranking. Rather, the citation is provided simply as a general reference for the particular topic being discussed." Such a broader inclusion of references related to the topic, whatever their perspective or degree of accuracy, is useful to anyone seeking more information. Future revisions of the method will make this the caveat more explicit to the reader.

With regard to the appropriateness of citing particular studies, it would have been impractical to critique the methods and assumptions of every cited study. Most cited references were subjected to peer review prior to publication. Publications that are reviews, rather than original research, are clearly identified as such throughout the document.

Streamlining

The cumbersomeness of the FHWA method is primarily in the interpretation keys, and plans are currently underway to computerize these keys. The keys are, in some cases, already dichotomous, a suggestion made by the Water Quality and Habitat Panels. Dichotomy is included both explicitly and in the supporting questions for the keys (e.g., "skip this question if system is tidal"). Attempts to make more of the responses dichotomous seemed unsupportable during the development of the FHWA method. However, this possibility will be rechecked during future revisions. The present arrangement of questions in the Form A questionnaire should be maintained, because the questions are organized according to similarity of concept and data availability.

Incorporating a "Red Flag" Feature

The inclusion of "red flag" features, as suggested by the Socio-Economic and Water Quality Panels, deserves further consideration. Criteria for these features will need to be very specific and developed with substantial public input. The most supportable critical features, such as threatened and endangered species, already exist as de facto red flags in other agency decisionmaking procedures.

RESPONSE TO ISSUES RAISED BY SPECIFIC PANELS

The following responses are to suggestions made by a single panel. The page and paragraph of the respective panel reports is noted for each point addressed. Space limits a full response to all of the points raised.

Hydrology Panel

Page 17, paragraph 3. I disagree with the panel that we lack enough knowledge to evaluate hydrologic processes in any wetland without careful measurements. For example, we can be certain that most marine wetlands do not recharge ground water.

Page 18, paragraph 1. Recharge and discharge are functions, as well as hydrologic processes, as are sediment trapping and shoreline anchoring. The result of their performance is something that can be useful to humans.

Page 18, paragraph 1. The FHWA system does not imply a higher value for recharge than discharge, as far as I can discern in Volume I, pp. 7-10, Volume 2, pp. 57-59, or the interpretation keys.

Page 19, number 1. The use of the term "basin" to mean "wetland plus deep water" is supported by Cowardin (1982). I welcome suggestions from hydrologists for a more exact term.

Page 19, Flood Storage Key number 2. Predictors 8 and 9 are mutually supported to a degree, i.e., wetlands high in watersheds (Predictor 9) are likely to have small subwatersheds (Predictor 8). Storm track considerations are useful, but probably of insufficient importance in the majority of situations to invalidate use of Predictor 9. Lowland wetlands may desynchronize runoff, but this is less certain (See Adamus 1983; Vol. I, p. 16).

Pages 20-21, Flood Storage Predictors 5, 6, 8, 9, 27, and 28. The numerical breaks are mostly arbitrary, as noted in Volume I. They probably are sufficient to separate out the most extreme conditions.

The following Panel suggestions seem useful in whole or part:

Page 19, number 3.

Page 20, numbers 4, 5(a,d,e), and 6.

Pages 20-21. Predictors 2, 14, 34, 43, 45, 56, and 66.

Page 21. Comments regarding fastland and unconsolidated shore.

Page 22. Predictors 4 and 37.

Water Quality Panel

I agree, at least partially, with all of the specific points raised.

Food Chain Panel

This discussion will deal with Table 1, "References" column. The quantifying of the references used in the FHWA method (pp. 44-47) by the panel, which suggests predictor inadequacy, is somewhat misleading and can either over- or underestimate the amount of available documentation. This quantification may underestimate the available documentation because not all of the relevent studies were cited under every predictor and because the literature seldom explicitly discusses some of the more obvious linkages (such as contiguity being essential to the out-of-basin transport of organic substances). On the other hand, the citing of references in the document does not necessarily imply that they support the ranking, only that they discuss the function.

Page 48, number 2. Assumptions based on estuarine systems were not applied automatically to all wetland types. Serious consideration was given to their applicability, based on known, indirect relationships when direct evidence of applicability was lacking.

Page 41, paragraph 2. While I support the Food Chain Panel's attempt to suggest alternative ways to evaluate the Food Chain Support function, their suggestion to use HEP or HES procedures or observations by biologists are inappropriate. Observations of biologists are likely to be nonrepresentative unless full-fledged field observation programs are funded for each wetland being evaluated. HEP and HES are oriented toward assessing habitat structure and deal only with values manifested within a basin. For example, a high HEP rating might be assigned to a wetland total in situ habitat for estuarine fish, in spite of the fact that the wetland exports little usable energy to surrounding systems (i.e., the food chain rating would be low). The FHWA system allows for the separate analysis of both the habitat and food chain functions.

Page 41, number 1. Predictors 1 and 2. It is not clear what still another peer-reviewed literature synthesis on food chain support could accomplish, over and above what already exists in the FHWA document (Volume I, Section 2.6) and Scott Nixon's review (in preparation) for the U.S. Army Corps of Engineerings (Waterways Experiment Station).

Page 50, Predictors 53 and 54. The Diaz (1982) reference is listed in the FHWA report (literature cited section) and was available to the public 11 months before the May workshop.

The following panel suggestions seem useful in whole or part:

Page 42. Research clearly is needed on the food chain support function of wetlands. The emphasis of the research should be on comparative aspects.

Pages 49-50. Predictors 24, 36, and 57.

Pages 51-53. Predictors 3, 4, 15, 23, 49, 59, 67, and 68.

Habitat Panel

Page 55, paragraph 2. The guidelines provided in the FHWA document for assessing the dynamic aspects of wetlands are probably adequate. The results to date suggest relatively good consistency among user outputs, and planned training sessions should further improve the consistency.

Page 56, paragraph 3. Farmed wetlands are recognized by question 39.2 in Form A. I welcome suggestions on practical guidance to solve this problem for field evaluators.

Page 56, paragraph 4. The importance associated with a wetland by virtue of its belonging to a wetland complex is difficult to assess. On one hand, the value of a "complexed" wetland may be high due to synergistic attractiveness to mobile species. On the other hand, isolated (noncomplexed) wetlands may be disproportionately valuable due to an "oasis" effect. Further advances in optimal foraging theory, as applied to wetland animals, will help define specific wetland pattern thresholds. This should be a high priority research topic.

Page 57, paragraph 4. The guild approach may be useful for detailed habitat assessments, but its requirements for comparing potential guild numbers to actual guild numbers would seem to render it impractical for rapid assesments, because even qualitative wildlife inventories of most wetlands are lacking and require site visits at several seasons.

Page 58, paragraph 1. A 1 to 5 rating scale would imply a degree of precision clearly not supportable by the present research database for most topics.

Nearly all of the remaining specific suggestions of the Habitat Panel are acceptable in whole or part.

Socio-Economic Panel

Page 69. Table 1, Part C. The proposed red flags are worded so that almost any wetland could be included. To illustrate this, examples of the most subjective terms in some of these proposed red flags are underlined below:

8. "Only wetland or one of a few wetlands near a population center."
9. "At least locally an unusual ecosystems..."
12. "Vital element to a wetland system"
13. "Has a rare, endangered, restricted, endemic, or relict flora or fauna..."
15. "Has a flora of unusually high visual quality."

Page 70. Recommendation number 1. It is not the purpose of the report to take an advocacy role. The panel's philosophy concerning wetlands protection is embodied in Executive Order 11990, which is one basis for the FHWA document.

Page 70. Table 2, potential Predictors 5 and 6. "Demographics" and "ecosystem stability" are very difficult predictors to set standardized thresholds for.

Page 72, paragraph 1. The further development of a detailed set of utility (or potential utilization) measures might be appropriate for some functions, but is likely to be highly subjective for others. The Water Quality Panel's suggestion that social significance concerns be handled on an agency-by-agency (and perhaps region-by-region) basis is, I believe, a sound one in most cases.

Most of the remaining specific suggestions of the Socio-Economic Panel are acceptable in whole or part.

Value Assessment Panel

All of the panel's specific recommendations are acceptable in whole or part, except for the suggestion to structure Form B and its interpretive guidance more along the lines of Form A (Value Assessment panel: p. 15, paragraph 2). Social significance concerns are best interpreted on an agency-by-agency or regional basis, in order to maximize assessment flexibility.

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APPENDIX C. WORKSHOP FOLLOW-UP PLAN

Development of A National Wetland Values Assessment System: A Proposed 4-Year Interagency Plan

The following is a detailed 4-year plan for follow-up of the National Wetland Values Assessment Workshop, to complete the development of a National wetland assessment method. Implementation of any method is dependent on the continued close cooperation of the agencies represented on the Wetland Values Coordinating Committee. The plan basically consists of three periods (tasks 1, 3, 5, and 7) of effort directed at revising the method, interspersed by two field testing periods (tasks 2 and 6) and concurrently scheduled regional workshops (task 4) and directed research.

TASK 1 - Revision of the Federal Highway Administration (FHWA) Wetland Values Assessment System.

The FHWA system will be revised in line with recommendations emanating from the May, 1983, values assessment workshop, from results of con-currently funded research, and from input from various State and Federal agencies attempting to adapt the system to fit their needs. Primary responsibility for this revision would rest on the principal author of the FHWA system.

Task 1 would involve five subtasks:

1.1 Computerization. The FHWA method, in its present form, would be placed in computer files such that: (1) responses to Form A and B questions could be analyzed rapidly (i.e., interpretation keys would be computerized); and (2) an interpretation key, its corresponding questions in Form A, and their corresponding documentation in Chapter 3 of Volume I, could be rapidly called up on the computer screen for fast cross-referencing. This is an absolute prerequisite for completion of subtask 1.4.

1.2 Refine Rankings and Documentation. The method will be updated using post-1981 literature and selected pre-1982 references that were previously overlooked. The most controversial or ambiguous rankings contained in the existing method will be identified and clarification sought through personal contacts with key researchers individually or in subsequent regional workshops (task 4). Identification of these assessment-related data gaps will be an invaluable aid to agencies preparing scopes of work for interrelated research. The integrity of citations now in text will be examined and existing typographic and referencing errors will be corrected.

1.3 Examine Inference Network Techniques. Inference networking is a computerized tool used in the branch of artificial intelligence known as Expert Systems. The interpretation keys that are the core of the FHWA method are, almost by accident, rudimentary inference networks. They are a series of interlocking hypotheses connected nonnumerically by logic statements. Formal inference networking techniques will be examined for their potential to: (1) fine tune the interpretation keys, so that responses are combined in a more exacting, perhaps more hierarchial manner; (2) assign uncertainty ratings to the wetland ratings ultimately generated; (3) allow the user to employ information gathered from previous answers to limit the range of meaningful follow-up questions; and (4) allow for calibration of the keys with wetlands of known functional or process value (sensitivity analysis).

1.4 Fine-tune Interpretation Keys. The existing interpretation keys will be revised either with or without use of an inference networking structure. Any existing "black boxes", dead ends, and multiple answers to the interpretation keys will be identified and explained or corrected. Fine-tuning at this point will be based on suggestions of May workshop participants, users to date, new literature, and a retracing of logic patterns by the author in concert with a small multidisciplinary team.

1.5 Apply Inference Network Techniques. In consultation with a recognized Expert System authority, the existing interpretation keys might be converted to the inference networking formalism. Delphi methods could be used to help specify uncertainties in the various linkages and combination rules. This subtask is potentially enormous, so carryover is expected into tasks 3, 5, and 7.

TASK 2 - Field Testing of the Revised FHWA system.

This Task will be divided into two subtasks that will be conducted concurrently:

2.1 Intensive field testing (calibration or sensitivity analysis) on a variety of wetlands for which there is a good database derived from long term research studies. These tests will involve wetland types within all of the Systems recognized in the FWS wetland classification system and, ideally, in all regions of the United States. Role of the Principal Investigator in this effort will be minor.

2.2 Intensive field testing by field personnel who will be representative of the potential prime users of the system.

Results of these tests will be forwarded to authors for analysis and for making appropriate alterations in the system.

Schedule:

Starting Date for Testing: April 1, 1985
Completion of Tests: July 31, 1985

TASK 3 - Revision of the Operational Draft Based On Results of the Field Tests and Regional Workshops.

The authors will evaluate the results of field testing, regional workshops, ongoing directed research, and new technical literature and then will make appropriate changes in the system. The application of inference network techniques for quantifying the method's uncertainly will be intensified. New functions (e.g., toxic chemical retention and silviculture) may be added and some existing ones (e.g., recreation and aesthetics) may be greatly strengthened. If Alaska and Hawaii are to be included, an extensive effort will be required at this point to formulate their extensive databases into an assessment method.

Schedule:

Starting Date: August 1, 1985
Completion Date: May 1, 1986

TASK 4 - Regionalization of the Standard National System

Plans call for a standard National wetland evaluation system that will have regional components reflecting unique regional differences in wetlands. In this regard, the system is analogous to language; we have a single National language with unique regional variations, called dialects. In like manner, a single National assessment system could easily accomodate regional variations, and yet be comprehensive to all users. To facilitate coordination and easy access to databases, the regions could correspond to those established by the National Wetland Technical Council. The assessment system would be supported by an automated (computerized) database system with regional referencing capability, as is now being developed jointly by the U.S. Fish and Wildlife Service and Army Corps of Engineers.

Regionalization of the FHWA method would be accomplished primarily through a series of highly structured regional workshops. The regional workshops presently planned by the National Wetland Technical Council for the purpose of identifying research gaps might, if funded, serve as the forum for posing a specific set of inference network-related questions to participants (perhaps through use of a Delphi procedure and/or questionnaires developed by the FHWA method author). Alternatively, similar groups of wetland authorities could be reconvened at another date for this purpose. In either case, participants will be asked to rank the uncertainty in various wetland hypotheses, note regional differences in the wetland rankings, and adopt regionally-specific criteria for "red flag" features.

This task is made up of two subtasks:

4.1 Prototype Regional Workshop - This workshop would examine regional wetland peculiarities that must be accommodated and establish a format for subsequent regional workshops. The region selected to serve as the prototype for regional workshops is not of critical importance; however, it would be advantageous to hold it in a region where the National Wetland Technical Council has already held one of their proposed wetland value workshops, if these are not held concurrently to the presently proposed workshops.

Participants in this workshop will represent users from the Federal, State, and private sectors within the region. A good mix of field and research workers will be sought. Attendance will be limited and by invitation only.

4.2 Regional Workshops - Workshops will be scheduled in each region. The format will be refined based on experience gained from the prototype workshop.

Schedule:

Prototype Workshop - April, 1985
Regional Workshops - (A total of six, with one held each month).
Starting Date: June 1, 1985
Completion Date: April, 1986

TASK 5 - Preparation of the Operational Drafts of the Regional Wetland Value Assessment Systems.

Much of this work will be concurrent with the regional wetland workshops and task 3.

Schedule:

Starting Date: August 1, 1985
Completion Date: May 31, 1986

TASK 6 - Field Testing of Regional Operational Drafts

Field testing will be conducted in the same manner as the tests of the National system. Results will be forwarded to the authors for analysis and for making appropriate alterations in the system.

Schedule:

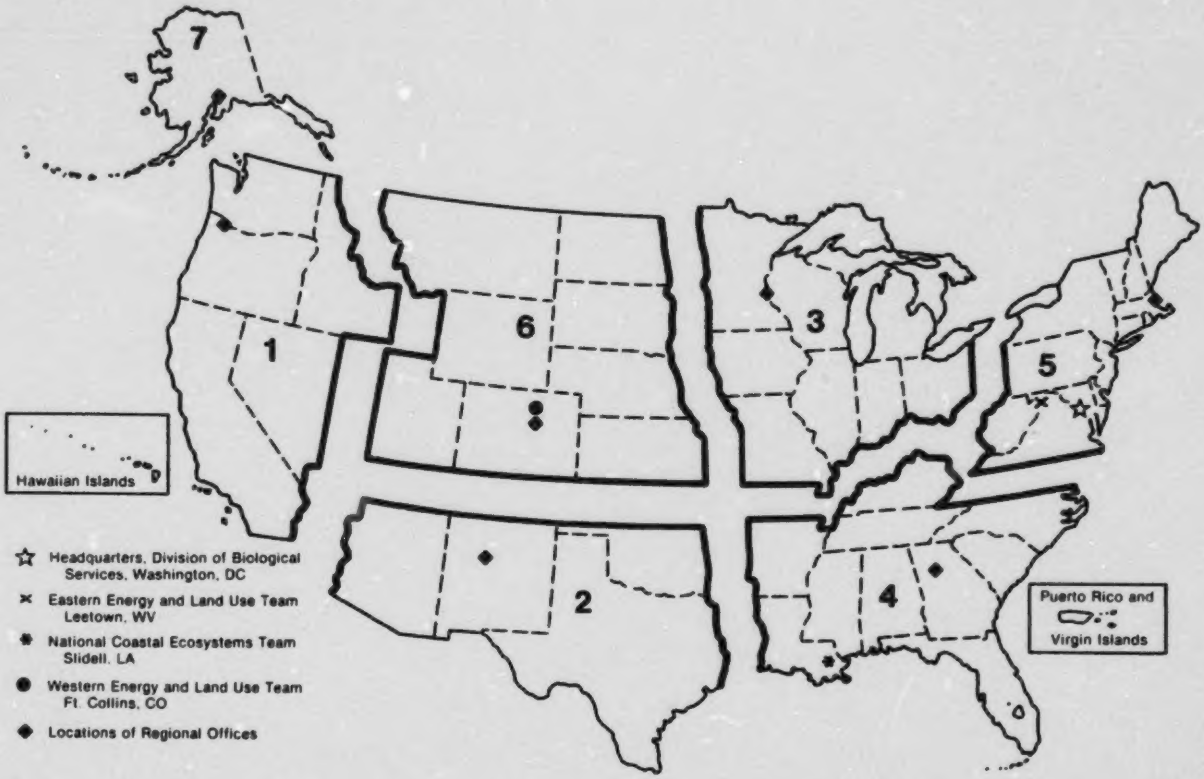
Starting Date: June 1, 1986
Completion Date: September 30, 1986

TASK 7 - Preparation of the Final Draft of the Wetland Value Assessment System, Including all of the Regional Adaptations.

This effort will involve incorporating results of the latest field testing, on going directed research, and technical literature. In addition, a major effort will be directed toward making the method more "user friendly" through use of numerous photographs and illustrations.

Schedule:

Starting Date: October 1, 1986
Completion Date: September 30, 1987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